Master thesis for the Master of Economic Theory and Econometrics degree

Is the bottleneck too tight?

The Balassa Samuelson Effect and its possible impact on EMU Accession Economies' ability to meet the Maastricht Inflation Criteria

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Preface

From the early struggling with mathematics to the revelation of its usefulness, learning economics has been an adventure. Experiencing how knowledge progressively leads to understanding, from believing that economics was only about numbers to appreciating how it affects everyday life, decisions and politics in its broadest sense, has been profoundly inspiring. The world looks different with the understanding of economics. I would like to thank associate professor Tor Martin Kvikstad at Buskerud University College for making mathematics come alive and professor Jon Vislie at the University of Oslo for believing in me and sharing his passion for this field of science.

This thesis was born out of my interest in European monetary policy and the challenges facing the new EU member states on their way toward full integration. Gathering the necessary data proved to be quite a challenge and I would like to thank Deputy director Ingvild Svendsen in Norges Bank for lending me an office for two weeks, making the collection process so much easier.

I would also like to thank my supervisors, professor Paul De Grauwe at Katholieke Universiteit Leuven and professor Steinar Holden at the University of Oslo for their valuable comments and discussion during the work. A special thanks also to professor Ragnar Nymoen at the University of Oslo for his friendly and most helpful econometric guidance.

I am also grateful to the Professorship in Macro and Monetary Policy Issues for granting me a scholarship for my work on this thesis.

Thank you to my parents for always being supportive and to “mormor” for making my exam preparation days happy memories.

Last, but above all, I thank my best friend and newly wedded husband, Jon Øyvind, for committed discussions, comments and proofreading, priceless motivation and for making every day invaluable.

Table of contents

1. Introduction and summary

The European Union grows eastwards. In 2004, ten Central and Eastern European Countries (CEEC) were admitted to the EU[1] and as of 1 January 2007, Romania and Bulgaria followed. A membership in the EU is meant to provide citizens with a lot of benefits. For the former communist states, membership was tantamount to final severance from Russia, being a member meant protection. EU membership also means a duty to uphold *the four freedoms*[2] which speeds up the market liberalization process. However, EU accession is only one step towards full integration in a common market. The final step is to adopt a common currency. To adopt the Euro, an EU member state must first qualify for membership in the European Monetary Union (EMU). This requires a two-step plan. First, the candidate state needs to become part of the Exchange Rate Mechanism II (ERMII), which means that they must keep their national currency within a range of ±15%, with respect to a central rate against the Euro. Second, the so-called Maastricht criteria must be fulfilled. Two of the Maastricht criteria are of special interest to this thesis. The first is the exchange rate criterion, stating that the candidate must have stayed within the ERM II band for at least 2 years. The second, the inflation criterion, states that the candidate's inflation rate must be no higher than or equal to 1,5 % above the average of the three best performers of the EU[3].

De Grauwe & Schnabl (2004) predicted that EMU entry for the countries joining the EU in 2004 would be within 2006. Only Slovenia has succeeded so far (from 1 January 2007), even though it was expected to be one of the countries that would have most trouble to meet the criteria (see Milhaljek & Klau (2004). So what went wrong?

In the summer months of 2006 the Estonian and Lithuanian applications to join the Eurozone were rejected because of the countries' failure to meet the Maastricht inflation criterion. Lithuania missed the target by only 0,1%. The rejection was a massive disappointment for the two countries that had been working very hard for their membership approval. A new target date set by the countries themselves is due in a few years - in 2010.

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[1] These ten were Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, the Slovak Republic and Slovenia.

[2] Free movement of goods, services, capital and labor.

[3] For a full description of the EMU Maastricht Criteria, see Nello, S.S. (2005), pp. 182

All candidates have signed an obligation to adopt the Euro in the EU Treaty of Accession and by that committed themselves to work towards fulfilling the Maastricht criteria. The Czech Republic, Hungary and Poland were on a positive track for a while, but now seem to be less enthusiastic, and are frequently postponing the target date. The Slovak Republic and Latvia on the other hand have not yet given up and their main challenge is, as in Estonia and Lithuania - inflation.

This thesis seeks to explore the reason for the high inflation rates in the three Baltic countries, and in the Slovak Republic, since that seems to be the main obstacle for their future Euro adoption. I look at these four candidate economies since they seem to be the next ones in line to qualify for EMU membership. Slovenia is also included in the analysis, since I find it very interesting to compare its performance with the others and since it, in spite of the negative predictions, became the first candidate from the East to join.

I have chosen to look for the existence of the Balassa-Samuelson effect, as this effect explains a natural economic mechanism stating that transition countries with high productivity growth in the tradable sector, and with equal nominal wage growth between the sectors, experience a temporary higher inflation rate than what you see in western Europe. This excessive inflation rate is supposed to vanish when the convergence process is completed (productivity growth flattens out). I look for the effect relative to the Euro area, individually for each country. Is it present? In that case could not an inflation rate slightly higher than the criteria rate be taken as proof of a healthy economy, showing that inflation is not out of control due to poor economic management, but rather a consequence of a successful transition? Based on the results I wish to explore if the inflation criteria can be fulfilled for a country in convergence or if the Maastricht bottleneck is too tight.

Previous studies agree that the effect is present in the CEEC, but conclude that the effect is likely to diminish (see e.g. Milhaljek & Klau (2004). It is also stated that when the Balassa-Samuelson effect is present, it is very difficult to fulfill the inflation criterion and the exchange rate criterion at once (Égert et al (2002).

The latest data samples I have found in empirical studies to this date include 2002 (e.g. DeGrauwe & Schnabl (2004), Lommatzsch & Tober (2004). The data sample in this thesis, by comparison, stretches to include the first quarter of 2007. A newer data sample might lead to different results than what have been seen before. If the effect is diminishing, as claimed by Milhaljek & Klau (2004), I should expect to find lower estimates for the Balassa-Samuelson effect than the ones presented in their paper.

The method that has been used to calculate the Balassa-Samuelson effect in previous studies has been a panel co-integration technique or VAR models[4]. This, combined with time series only available as annual data, led to the assumption of a large degree of homogeneity among the accession countries. Milhaljek & Klau (2004) (M&K) argue that these earlier studies calculate a "domestic" Balassa-Samuelson effect, the so called Baumol-Bowen effect[5], only stating that there is a higher inflation in the overall economy based on higher productivity in the tradable sector. To calculate the international Balassa-Samuelson effect however, they argue that the individual countries' performance must be compared to the performance of the Euro area. They argue further that this way of calculating the Balassa-Samuelson effect improves upon previous studies by providing a more precise estimate and that this estimate is lower than the one found by calculation of the "domestic" effect. They also argue that their data are more disaggregated and that the data sample is much larger and more detailed, so that they can use time series instead of an imprecise panel when presenting the data (which opens up for more heterogeneity across countries).

In this thesis I too calculate the "international" Balassa-Samuelson effect and follow the M&K approach with respect to the collection of quarterly disaggregated data, but surpass their paper by a twelve quarter enlargement of the data sample. When taking the theoretical model to the data, M&K do this in a somewhat incorrect way so the methodology used in this thesis is fairly different. The estimation of the Balassa-Samuelson effect will be done in two ways. First, only the change in the nominal exchange rate and the difference in productivity growth will be used as explanatory variables. Second, differences in relative wage growth will be included as an additional explanatory variable for all countries except Slovenia (due to lack of data). The latter approach arise from the fact that the assumption of wage growth equalization between the two domestic sectors not necessarily is fulfilled. All estimation is done in Givewin2, using the PcGive10 module.

[4] See e.g. Égert et al (2002), Coricelli & Jazbec (2001), Halpern &Wyplosz (2001), DeBroeck-Sloek (2001).

[5] Baumol W. and Bowen W. (1966) states that prices on service-intensive goods have had a steady growth over time, even if productivity growth related to such goods was considerably lower than in the productivity growth related to more capital–intensive goods.

I find that the Balassa-Samuelson effect is present in Latvia and Lithuania and that the effect rather has increased than diminished in recent years. In the Latvian case the effect is rather small, explaining approximately 0,02 percentage points of the inflation differential when estimated over the whole sample period and 0,7 percentage points when focusing on recent years. For Lithuania both the effect in general and the increase in recent years are larger, explaining about 0,4 percentage points of the inflation differential over the whole sample period and as much as 2,2 percentage points in more recent years. In the Slovak Republic the effect is significant, but has the wrong sign, which is puzzling. I also find that changes in the nominal exchange rate vis-à-vis the Euro have an effect on the inflation differential between the accession country and the Euro area, but this effect is smaller than the one through the relative labour productivity differential, for all countries but Slovenia. The relative wage growth differential incorporated as an additional explanatory variable, turned out to have no significant effect on the inflation differential in any country, including the ones experiencing non-uniform wage growth. For Estonia I only obtained significant results for changes in the exchange rate which is strange and, as discussed later; I suspect errors in the Estonian data.

The results lead me to the conclusion that the transition process is not yet over in the countries in study. The Balassa-Samuelson effect is still present, but small in Latvia and Lithuania over the whole sample period, meaning that it is not able to explain a lot of the inflation differential, but that at least some of the difference in inflation rates between the candidates and the Euro area is due to a "natural" development. The effect has been rather large in Lithuania in recent years and definitely present when the country applied for EMU membership in 2006. Had only a small part of the effect been allowed for then, as a sign of naturally higher inflation, Lithuania might have been an EMU-member today. The significant effect of changes in the nominal exchange rate on the inflation differential leads me to conclude that fulfilling both the exchange rate criterion and the inflation criterion at the same time might be easier if the exchange rate is not entirely fixed, but allowed to vary within the ERM II band. These results are discussed in detail in section 5.3 and section 6.

The remainder of this thesis is organized as follows: Section 2 gives the theoretical presentation of the Balassa-Samuelson model used as a point of departure for estimating the Balassa-Samuelson effect. Section 3 subsequently describes the empirical framework while section 4 yields an illustration of the development of the different components affected by the model over time. Section 5 presents the empirical results and section 6 concludes.

2. The Balassa Samuelson Model

The Balassa-Samuelson effect is based on a two sector model for a small open economy, one sector producing tradable goods and one sector producing non tradable goods. The model offers a supply side explanation for the behaviour of the relative price of non tradable goods in terms of tradable goods in an economy. It states that if a country experiences a higher productivity growth in the traded sector than in the non-traded sector this will, based on certain assumptions, lead to an increase in the relative price of non tradable goods which again will elevate the overall inflation in the economy. This outcome is then used to explain inflation differences between the two countries.

The model takes its name after Paul Samuelson and Bela Balassa. In 1964 they discovered that developing countries in convergence toward a steady state experienced a higher productivity growth in the tradable sector than what could be seen in already industrialized countries. They also found that the developing countries had higher inflation because of this excessive productivity growth[6].

The Balassa-Samuelson effect has been observed by several previous studies in most of the new eastern EU member countries, in the years after the fall of communism. Since these countries have been and still are in the middle of a catch-up process in their transition to market economies, this is not surprising given that the development first becomes visible in the tradable sector. The countries climbed out of the Soviet regime with a very low developed service sector and a more developed, but highly inefficient industrial sector. During the era of communism the industrial sector consisted solely of state owned enterprises (SOEs) and the performance of these enterprises was unbelievably inefficient. After the fall of communism it was therefore a lot easier to increase the efficiency in the industrial (tradable) sector (making it more productive) than to build up a service sector from ground zero. The idea is that the additional inflation due to this productivity growth differential will fade out as the convergence reaches its completion. The effect is usually based on the Balassa-Samuelson

[6] cf. Balassa, B. (1964) and Samuelson, P. (1964).

model described in detail below.

The following assumptions are often made to make sure that the relative price of non tradables is fully explained by supply conditions (so that demand/preferences will not matter at all):

- There is perfect competition in the market for tradable goods so by the law of one price[7], prices on tradables will be the same in all countries and will be taken as exogenous.

- Capital is perfectly mobile, both between sectors and countries while labour is perfectly mobile between sectors, perfectly immobile between countries. This intercountry (intersectoral) mobility indicates that if the countries (sectors) have identical technologies, but different factor endowments and if both countries need the same type of capital (labour) and if no factor intensity reversal occurs, then the Factor Price Equalization Theorem (Samuelson 1949) states that factor prices (rental rate on capital and wage level) are equalized across countries (sectors)[8]. This means that the rental rate on capital will be taken as exogenous and determined on the world market. The wage level of the tradable sector will be decided endogenously and the wage level of the non tradable sector will then be set equal and is therefore taken as exogenous.

- Perfect competition is also assumed in the market for non tradable goods, but there is no direct competition between countries and also no competition between the two sectors within a country.

All these assumptions are not necessary for the Balassa-Samuelson effect. Wage equalisation between sectors and firms using constant mark-ups are sufficient to make sure differences in productivity growth between sectors lead to differences in price growth.

Production in each sector is characterized by constant return to scale and the production of the two goods is described by the following Cobb Douglas functions:

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7 The law of one price states that in the same open market, at any moment, there cannot be two prices for the same kind of article. If it were, arbitrage should occur until the prices converge (This is the arbitrage view of Purchasing Power Parity).

8 See Feenstra, R. (2004).

$$Y^T = A^T (L^T)^{\gamma} (K^T)^{1-\gamma} \qquad , \; 0 < \gamma < 1 \tag{1}$$

$$Y^{NT} = A^{NT} (L^{NT})^{\mu} (K^{NT})^{1-\mu} \qquad , \; 0 < \mu < 1 \tag{1′}$$

where Y, L, K and A denotes output, labour input, fixed capital input and total factor productivity (TFP) respectively. TFP, as a measure of technology, is assumed exogenous, the total amount of capital and labour is fixed and there is no waste of resources. T and NT stand for tradable and non tradable sector while γ and μ are the intensity of labour in the two sectors. The time dimension is here omitted, since the theory is generally believed to hold in the long run.

If these assumptions hold, then the relative price of the non tradable good in terms of the tradable good can be solely determined from the supply conditions. This follows by calculating the first order conditions from the following profit maximization problems:

$$\pi^T = P^T Y^T - W^T L^T - i^T K^T \tag{2}$$

$$\pi^{NT} = P^{NT} Y^{NT} - W^{NT} L^{NT} - i^{NT} K^{NT} \tag{2′}$$

where π^T, π^{NT} denotes the profit in each sector, P^T, P^{NT} denotes the price on each good, W^T, W^{NT} stand for the nominal wage in each sector and i^T, i^{NT} represent the interest rate as the nominal rental rate on capital. Profit maximization then implies:

$$\frac{\partial \pi^T}{\partial K^T} = (1-\gamma) P^T A^T (L^T)^{\gamma} (K^T)^{-\gamma} - i^T = 0 \tag{3}$$

$$\Rightarrow r^T = (1-\gamma) A^T \left(\frac{K^T}{L^T}\right)^{-\gamma}$$

$$\frac{\partial \pi^{NT}}{\partial K^{NT}} = (1-\mu) P^{NT} A^{NT} (L^{NT})^{\mu} (K^{NT})^{-\mu} - i^{NT} = 0 \tag{4}$$

$$\Rightarrow r^{NT} = (1-\mu) \frac{P^{NT}}{P^T} A^T \left(\frac{K^{NT}}{L^{NT}}\right)^{-\mu}$$

$$\frac{\partial \pi^T}{\partial L^T} = \gamma P^T A^T (L^T)^{\gamma-1}(K^T)^{1-\gamma} - W^T = 0 \tag{5}$$

$$\Rightarrow w^T = \gamma A^T (\frac{K^T}{L^T})^{1-\gamma}$$

$$\frac{\partial \pi^{NT}}{\partial L^{NT}} = \mu P^{NT} A^{NT} (L^{NT})^{\mu-1}(K^{NT})^{1-\mu} - W^{NT} = 0 \tag{6}$$

$$\Rightarrow w^{NT} = \mu \frac{P^{NT}}{P^T} A^{NT} (\frac{K^{NT}}{L^{NT}})^{1-\mu}$$

where r^T, r^{NT} is the real rental rate on capital while w^T, w^{NT} is the real wage for the two sectors all with the price of the tradable good as the numeraire. $\frac{P^{NT}}{P^T}$ is the relative price of the non tradable good in terms of the tradable good. As explained above perfect intersectoral factor mobility validates the following definitions:

$w^{NT} = w^T = w \quad , \quad r^{NT} = r^T = R$

Equations (3) – (6) hence have 4 unknowns: $(w, \frac{P^{NT}}{P^T}, \frac{K^T}{L^T}, \frac{K^{NT}}{L^{NT}})$ and the system of equations has a unique solution (equation (3) determines the capital labour ratio for the tradable sector which again solves for the tradable wage in equation (5). Due to wage equalisation the non tradable sector adjusts the price of the non tradable good so that $\frac{P^{NT}}{P^T}$ and $\frac{K^{NT}}{L^{NT}}$ are determined by equation (4) and (6) jointly).

This unique solution to the Balassa-Samuelson model, ending up with showing that the log relative price of non tradables depends only on technology and the exogenous rental rate on capital is fully derived in Appendix A. Taking the model to the data, however, discloses that obtaining good data on capital and technology in the accession countries is not yet possible so in the attempt to estimate the Balassa-Samuelson effect, labour productivity has to be used as a proxy for total factor productivity (TFP). The rest of the chapter therefore cultivates the effect of labour productivity on the relative price of the non tradable good in terms of the tradable good, since that yields a more appropriate starting point for the empirical analysis, at least for now. One weakness by this approach is that a change in the capital stock will affect labour productivity while TFP will remain the same. The capital stock is therefore assumed to be fixed in the further analysis.

To show that an increase in the relative price of non tradables $\frac{P^{NT}}{P^T}$ can be explained by an increase in the relative labour productivity of the tradable sector $\frac{LP^T}{LP^{NT}}$, equation (5) and (6) are rearranged in the following way:

$$w = \gamma\left(\frac{A^T (L^T)^{\gamma} (K^T)^{1-\gamma}}{L^T}\right) = \gamma \frac{Y^T}{L^T} \Leftrightarrow \gamma LP^T \qquad (5')$$

$$w = \mu \frac{P^{NT}}{P^T}\left(\frac{A^{NT} (L^{NT})^{\mu} (K^{NT})^{1-\mu}}{L^{NT}}\right) = \mu \frac{P^{NT}}{P^T} \frac{Y^{NT}}{L^{NT}} \Leftrightarrow \mu \frac{P^{NT}}{P^T} LP^{NT} \qquad (6')$$

Setting (5′) equal (6′), solving for $\frac{P^{NT}}{P^T}$ and multiplying by (-1) yields:

$$\gamma LP^T = \mu \frac{P^{NT}}{P^T} LP^{NT} \Rightarrow -\frac{P^{NT}}{P^T} = -\frac{\gamma}{\mu} \frac{LP^T}{LP^{NT}} \qquad (7)$$

Equation (7) presents a version of the domestic Balassa Samuelson effect saying that the relative price of the non tradable good in terms of the tradable good will increase if labour productivity in the tradable sector increases, assuming no change in labour productivity in the non tradable sector.

This domestic Balassa-Samuelson effect is displayed graphically in Figure 1[9]. The production possibility frontier (PPF) AB is derived from the two production functions (1) and (1') and due to the fact that the economy is not wasting resources it is assumed to produce on the frontier, but all points down and to the left are as well possible. For given input factors and technology any points up and to the right are unreachable. The slope is given by the right hand side of equation (7), $-\frac{\gamma}{\mu} \frac{LP^T}{LP^{NT}}$, giving an indication on how much you have to stop producing of the tradable good to produce one extra unit of the non tradable good when

[9] This figure and the calculation of equation 7 is originally from DeGrauwe P. and Schnabl G. (2004) Some changes are made.

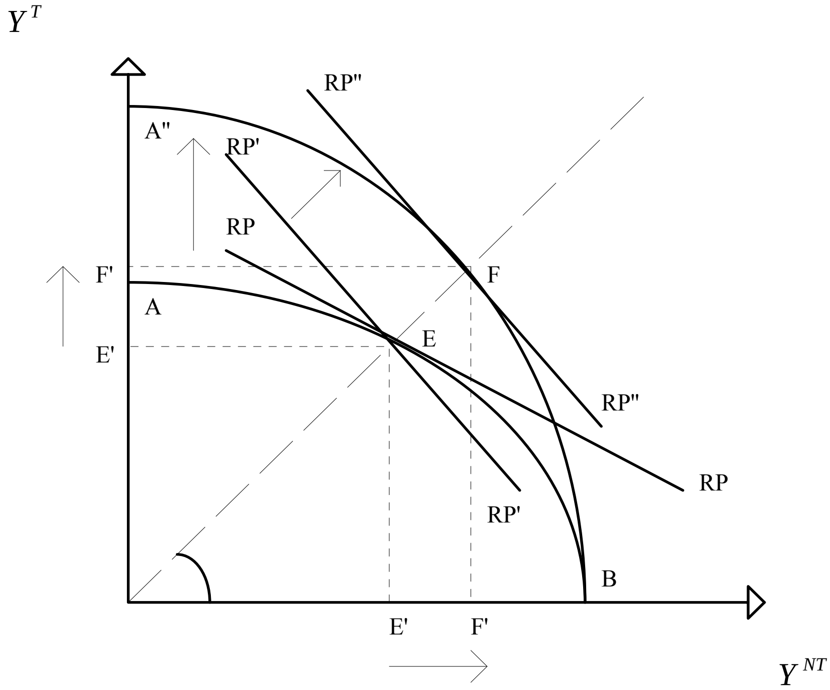
producing at any point on the PPF. The curve is steeper the more productive labour is in the tradable sector compared to the non tradable sector and vice versa. This effect is reinforced the more labour intensive the one sector is compared to the other. The curve is concave since it is assumed that $\frac{\partial^2 Y^i}{\partial L^i} < 0$, $i = T, NT$. The economy is in equilibrium in point E where equation (7) holds by equality. It is needless to say that the slope of the relative price line RPRP is the left hand side of equation (7) $-\frac{P^{NT}}{P^T}$. In the equilibrium point E the amount needed to give up of the tradable good to buy one extra unit of the non tradable good in the market is exactly the same as the amount of Y^T that *has* to be given up in order to produce the extra unit of the non tradable good.

The purpose of this graph is to show the effect of increased productivity in the tradable sector. As a simplification it is assumed that the consumption of the two goods stand in a fixed relationship to each other and hence are insensitive to relative price changes (the consumers have a Leontief Utility function). The 45° line is chosen as the line representing this fixed relationship. Production will adjust in the same way, to meet demand. The equilibrium point will therefore always be on the 45° line. Another simplification in the graph is that productivity growth in the non tradable sector is zero. An increase in tradable sector labour productivity, while non tradable sector labour productivity remains the same changes the shape and the position of the PPF. While the intersection on the x-axis remains the same, the intersection on the y-axis moves from A to A''. More of the tradable good can be produced with the same amount of workers. Since the tradable workers are more valuable they require a higher wage and this wage increase spreads into the non tradable sector, as explained above, followed by an increase in the price of the non tradable good. Hence, the relative price line becomes steeper and is now equal to the line RP'RP'. Due to the fact that consumers are only willing to consume a fixed share of each good, resources must be moved from the tradable to the non tradable sector in order for supply to meet demand[10].

In F the economy is again in equilibrium. An increase in tradable sector labour productivity, while non tradable sector labour productivity remained constant, has led to a higher relative price on non tradable good, higher wages in both sectors and higher production of both goods.

[10] Move along the 45° line from E to F and displace the relative price line RP''RP'' parallel to RP'RP'.

Figure 1: The domestic Balassa – Samuelson effect



It has now been established that an increase in labour productivity in the tradable sector higher than in the non tradable sector will, subject to the assumptions, increase the relative price of the non tradable good in terms of the tradable good. As already mentioned in the introduction, Milhaljek and Klau (2004) claim in their paper that this, however, is not sufficient to imply a Balassa-Samuelson effect in an economy. The effect established can best be described as a domestic Balassa-Samuelson effect, closely related to the Baumol-Bowen effect. To establish a Balassa-Samuelson effect they argue that a comparison has to be made to another country, to see if differences in inflation rates can be explained by differences in productivity growth.

To follow this approach it is a good idea to first present a decomposition of the aggregate price level in the economy (use lower case to denote logarithms)[11]:

$$p_t = \alpha_t p_t^T + (1-\alpha)_t p_t^{NT} \qquad (8)$$

[11] Before taking logs the expression is the following: $P_t = (P_t^T)^{\alpha} (P_t^{NT})^{1-\alpha}$

$$p_t^* = \alpha_t^* p_t^{T^*} + (1-\alpha^*)_t\, p_t^{NT^*} \quad (8')$$

The components are evidently one tradable and one non tradable and the decomposition is done for two countries, one home country, in this analysis that will always be the accession country, and one foreign country, the euro area, the latter denoted by a star ("*"). The time dimension has been excluded so far due to the fact that the theory is viewed as holding in the long run, but is now included since the study at this moment is approaching the more empirical analysis. The α indicates the share of tradable goods in the economy. It also has a time dimension since it is assumed to vary over time as the accession economy develops. The behaviour of prices has a large implication on the dynamics of the real exchange rate. The well-known definition for the real exchange rate is:

$$Q_t = \frac{E_t P_t^*}{P_t} \quad (9)$$

where E_t is the nominal exchange rate saying, in this analysis, how much has to be given of the national currency to by 1 Euro and P_t, P_t^* are the nominal aggregate price levels.
Taking logs:

$$q_t = e_t + p_t^* - p_t \quad (9')$$

Substituting for (8) and (8') in (9'), expressing the equation in terms of first differences and manipulating by adding and subtracting Δp_t^T and $\Delta p_t^{T^*}$ gives the following expression:

$$\begin{aligned}\Delta q_t &= \Delta e_t + \Delta p_t^{T^*} + \Delta p_t^T - \Delta p_t^{T^*} - \Delta p_t^T \\ &\quad + (\alpha^* \Delta p_t^{T^*} + (1-\alpha^*)\Delta p_t^{NT^*}) - (\alpha \Delta p_t^T + (1-\alpha)\Delta p_t^{NT}) \\ \Rightarrow \Delta q_t &= (\Delta e_t + \Delta p_t^{T^*} - \Delta p_t^T) \\ &\quad + \left[(1-\alpha^*)(\Delta p_t^{NT^*} - \Delta p_t^{T^*}) - (1-\alpha)(\Delta p_t^{NT} - \Delta p_t^T)\right] \quad (10)\end{aligned}$$

Since it is assumed that the law of one price holds in the tradable sector the following expression will also hold by equality:

$$\Delta p_t^T = \Delta e_t + \Delta p_t^{T^*} \quad (11)$$

which turns the first term on the right hand side of equation (10) into zero, hence

$$\Delta q_t = (1-\alpha^*)(\Delta p_t^{NT^*} - \Delta p_t^{T^*}) - (1-\alpha)(\Delta p_t^{NT} - \Delta p_t^{T}) \quad (10)$$

stating that the dynamics of the real exchange rate is completely driven by the changes in the relative price of the non tradable good in terms of the tradable good between the two countries.

An expression for the change in the relative price in the two sectors can be found by log-differentiating equation (7):

$$\Delta p_t^{NT} - \Delta p_t^{T} = \log(\frac{\gamma}{\mu}) + \Delta lp_t^{T} - \Delta lp_t^{NT} \quad (12)$$

A similar equation will exist in the foreign country:

$$\Delta p_t^{NT^*} - \Delta p_t^{T^*} = \log(\frac{\gamma^*}{\mu^*}) + \Delta lp_t^{T^*} - \Delta lp_t^{NT^*} \quad (12')$$

The log labour intensity ratio indicates that even if the labour productivity growth is the same in both sectors there will still be a change in the relative price if the labour intensity is higher in the tradable sector than in the non tradable sector $(\gamma > \mu)$. Since it is most likely to believe that the contradictory is true $(\gamma < \mu)$ it can be expected that if the labour productivity growth is balanced between the sectors this might lead to a depreciation of the relative price of non traded goods. This is an especially interesting result in view of the fact that if the same analysis is done looking at total factor productivity (TFP) growth differentials (see Milhaljek and Klau (2004), Froot and Rogoff (1985), which is the unique way to solve the Balassa-Samuelson model analytically (see Appendix A), the result is the total opposite: If the non tradable sector is more labour intensive, $\gamma < \mu$, then a balanced growth of productivity will lead to an appreciation of the relative price of non tradable goods[12].

Inserting (12) and (12') into (10), substituting out for Δq_t on the left hand side when knowing that $\Delta q_t = \Delta e_t + \Delta p_t^* - \Delta p_t$ and multiplying both sides by (-1) yields the final expression:

$$\Delta p_t - \Delta p_t^* = \Delta e_t + (1-\alpha)_t \left[\log(\frac{\gamma}{\mu}) + \Delta lp_t^T - \Delta lp_t^{NT} \right] \qquad (13)$$

$$- (1-\alpha^*)_t \left[\log(\frac{\gamma^*}{\mu^*}) + \Delta lp_t^{T^*} - \Delta lp_t^{NT^*} \right]$$

which states that the differences between inflation rates in an accession country and the euro area can be explained by changes in the exchange rate EUR/NAC where NAC is national currency, and/or some sort of weighted average of the productivity growth differentials between tradable and non tradable sectors in the accession country and the Euro area. As can be seen, more weight is given to the country the lower the share of tradables in its economy, α, is.

Equation (13) forms the point of departure for the empirical analysis in this thesis and for the estimation of the Balassa – Samuelson effect. The choice of calculating it as a function of labour productivity, in stead of as a function of total factor productivity is made because of the difficulties in obtaining reliable data for capital and technological progress. If those data were available however, their theoretical counterparts should definitely be included in the analytical framework.

[12] The reason why this is emphasized is that labour productivity is used as a proxy for TFP in the empirical analysis in the studies mentioned due to lack of data. Therefore what is really estimated is the effect of labour productivity growth differentials on the inflation differentials between two countries and equation (13) is hence a more appropriate equation to initiate from when estimating the Balassa Samuelson effect, mind you, as long as the problem with lacking trustworthy TFP data consists. In the empirical analysis it will be assumed that labour intensity is the same in both sectors such that the first term in equations (12) and (12') will be equal to zero. In that way the computation is exactly the same in this study and the previous studies mentioned, only the interpretation of the initial equation differs.

3. Empirical Framework

The purpose of this thesis is to investigate the possible existence of a Balassa-Samuelson effect in Estonia, Latvia, Lithuania, the Slovak Republic and Slovenia, the latter being the only Central Eastern European Country (CEEC) so far allowed to adopt the euro[13]. The article by Milhaljek and Klau (2004) (M&K) has been used as benchmark when taking the Balassa-Samuelson model to the data. The empirical analysis employed in the thesis has, however, been structured differently from that of M&K. There are several reasons for this. The most important is that the M&K article has specified the empirical equations in a somewhat incorrect way (see further discussion below). Since new data has become available and it would be of more current interest to study a different set of (accession) countries in the EU, an improved structure has been created to better support the objective of this thesis.

3.1 Dividing into sectors

A natural point of departure for the empirical analysis is to split up the economy in a tradable and a non tradable sector. How to do this is debatable. One simple division, suggested by De Gregorio, Giovannini and Wolf (1994), is that a category belongs in the tradable sector if more than ten per cent of the production is exported. Regrettably it has not been possible to obtain this type of information during the work on this thesis. Based on the information received from the statistical bureaus in the representative countries, these sorts of data "do not exist". The academic literature has not come to an agreement on how to do this division and Table 1 gives an overview on the choices made by some of the previous studies on this topic. As can be seen here, there is no consensus on how to perform the division, but what they all seem to agree on is the fact that manufacturing or the aggregated industry category (containing manufacturing, mining, quarrying and energy), belongs to the tradable sector, while services belong to the non tradable sector. Another common factor is that agriculture and public services are mainly excluded from the analysis. The reason for the exclusion of agriculture is that reliable data are difficult to retrieve since agricultural prices are highly disturbed by the Common Agricultural Policy (CAP) of the EU, leaving the prices not fully

[13] The republic of Slovenia adopted the euro as their national currency 1 January 2007 locking the exchange rate at 239, 64 Slovenian Tolar per Euro.

market-determined[14]. In addition lucrative subsidy agreements thanks to the CAP make the value added data less trustworthy, so all in all it seems like a considered decision to exclude the agriculture category. Fishing is also excluded by the same argument[15]. Due to the fact that the data on agriculture are linked together with data on forestry and hunting, the two latter are also excluded from the analysis. A motivation for excluding public services on the other hand is that the value added data reported from education, health and public administration could be somewhat spurious, since only the production side of the economy is considered.

Table 1. Overview of the division into sectors in previous studies

Author	Tradable sector	Non tradable sector	Excluded variables
De Gregorio, Giovannini & Krueger (1994)	Industry Energy	Services	Public services
Kovács (2002)	Manufacturing	Services	Energy Public Services Agriculture
Golinello & Orsi (2001)	Manufacturing	Rest	None
Tyrväinen (1998)	Manufacturing Transportation	Services	Public Services Agriculture
Rother (2000)	Manufacturing	Rest	Agriculture
Egert (2002)	Industry	Not considered	
Cipriani (2001)	Industry Mining	Services	Agriculture
Fischer (2002)	Industry	Services	None
Arratibel et al (2002)	Manufacturing	Not considered	
Milhaljek, D. & Klau M. (2004)	Mining&Quarrying Manufacturing Hotels&Restaurants Transport&Communication	Electricity, Gas & water supply Construction Whole sale & retail trade Financial intermediation Real estate, business & renting activities Education Health	Agriculture Fishing Forestry Hunting Public administration

Table 1 shows that Milhaljek and Klau (M&K) have been much more comprehensive when dividing into sectors than the other studies displayed and this thesis will in some measure follow their approach. The deviations are some by choice and some by necessity due to lack

[14] Article 39 of the Treaty of Rome set out the initial objectives of the CAP, but there have been many reforms since then, the last in 2003. More information about the functioning of the CAP can be found on www.europa.eu.int/comm/agriculture.

[15] As a result of the Common Fisheries Policy (CFP), fully operative from 1983. An introduction to the CFP can be found on www.europa.eu.int/comm/fisheries.

of data. Ironically, obtaining detailed sector classification data for the CEEC was no problem, while finding the same data for the Euro Area proved to be impossible. Only a more aggregated classification was available and hence the division into a tradable and a non tradable sector ended up being more problematic than first assumed.

The aggregated classification is as follows (capital letters give the short version):

- A+B = Agriculture, Hunting and Forestry + Fishing
- C+D+E = Mining and Quarrying + Manufacturing + Electricity, Gas and Water Supply
- F = Construction
- G+H+I = Whole Sale and Retail Trade + Hotels and restaurants + Transport and Communication
- J+K = Financial Intermediation + Real Estate, Renting and Business Activities
- L+M+N = Public Administration and Defense + Education + Health

For the data to be comparable between the countries under consideration the lack of detailed EMU data had to be taken into account and therefore the sector division reported in Table 2 will lay the foundations for further analysis.

Table 2. Overview of the division into sectors in thesis

Author	Tradable sector	Non tradable sector	Excluded variables
Larsson Midthjell, N. (2007)	C (Mining&Quarrying) D (Manufacturing) E (Electricity, Gas & water supply (energy)	F (Construction) G (Whole sale & retail trade) J (Financial intermediation) K (Real estate, business & renting activities) H (Hotels & Restaurants) I (Transport & Communication)	A (Agriculture, hunting & forestry) B (Fishing) L (Public administration) M (Education) N (Health)

As can be seen from Table 2 this is a slightly different division than the one by M&K. Education (M) and Health (N) are excluded as part of the public services package M+N+L. As explained above, excluding all public services seems like a well-considered decision, since it is difficult to find trustworthy data. Electricity, gas and water supply (E) is aggregated with Manufacturing (D) and Mining & Quarrying (C) and is therefore placed in the tradable sector. Due to the fact that this has been a rather closed sector, at least up to recently[16], this is a bit misplaced. In the future however, when liberalization of the markets is more developed, it might be a reasonable switch. Continuing the comparison to M&K, hotels and restaurants (H) and transport and communication (I) are moved from the tradable to the non tradable sector since the two categories are aggregated together with whole sale and retail trade (G). All three categories G+H+I include tradable parts, but in view of the fact that their main focus is on the domestic market, it seems reasonable to place the aggregated category under non tradables. In this thesis the division into a tradable and non tradable sector is as presented in Table 2, but the results must be considered with some caution due to the sensibility of the sector division.

3.2 Testable equations

Equation (12) and (12') gives an analytical solution to the Balassa-Samuelson model where differences in labour productivity growth explain differences in price growth between the tradable and non tradable sector in an economy. It has been emphasized that even though the original solution of the Balassa-Samuelson model displays differences in total factor productivity (TFP) growth as the explanatory variable for differences in price growth between the two sectors (see Appendix A), such data are (yet) not available, so empirical studies must use data for labor productivity growth as a substitute. Equation (13) presents the analytical solution to the model when combining two countries and it is from this equation the empirical analysis will depart.

Recall equation (13):

$$\Delta p_t - \Delta p_t^* = \Delta e_t + (1-\alpha)_t \left[\log(\frac{\gamma}{\mu}) + \Delta lp_t^T - \Delta lp_t^{NT} \right] \qquad (13)$$
$$- (1-\alpha^*)_t \left[\log(\frac{\gamma^*}{\mu^*}) + \Delta lp_t^{T^*} - \Delta lp_t^{NT^*} \right]$$

where Δp denotes the inflation, the asterisk indicates that the variable describes the foreign country (in this analysis the foreign country will always be the Euro area) and Δe denotes change in the home countries' nominal exchange rate vis-à-vis the Euro area. (1-α) indicates

[16] The "EU Liberalization Directives for Electricity and Gas" from 1999 kick started the liberalization process and has led to a steady development towards a open market for energy. See www.europa.eu

the share of non tradables in the economy and Δlp_t^i , i = T, NT, denotes the productivity growth in the respective sector. The variables γ and μ represent labour intensity in the tradable and the non tradable sector respectively. In the empirical analysis I will assume that the labour intensity is the same in both sector, i.e. γ = μ.

When taking the Balassa Samuelson model to the data, the following specification of equation (13) is made[17]:

$$\log(\frac{CPI_t}{CPI_{t-1}}) - \log(\frac{CPI^*_t}{CPI^*_{t-1}}) = c + \beta_1 \log(\frac{E_t}{E_{t-1}}) + \beta_2 \begin{bmatrix} (1-\alpha)_t \left(\log(\frac{LP^T{}_t}{LP^T{}_{t-1}}) - \log(\frac{LP^{NT}{}_t}{LP^{NT}{}_{t-1}}) \right) \\ -(1-\alpha^*)_t \left(\log(\frac{LP^{T^*}_t}{LP^{T^*}_{t-1}}) - \log(\frac{LP^{NT^*}_t}{LP^{NT^*}_{t-1}}) \right) \end{bmatrix} + \varepsilon_t \qquad (14)$$

where CPI represents the consumer price index, E denotes the nominal exchange rate index in the home country vis-à-vis the Euro area and LP_t^i , i = T, NT, denotes the labour productivity index for the two sectors in each country. c is a constant and ε_t is the error term, included since this now is an econometric testable expression. The variables are represented as time series and also as first differences, since the point of interest is to see to what extent differences in inflation between the country in study and the Euro area can be explained by differences in relative labour productivity growth and changes in the nominal exchange rate. Equation (14) is hence the first testable equation.
The assumption concerning wage growth equalization in the two sectors is not necessarily fulfilled. As will be elaborated in section 4, Estonia and Lithuania experience a non uniform wage growth while Latvia, the Slovak Republic and to some extent the Euro area, seem to

[17] To create a testable equation based on equation (13) this thesis initially followed the presentation in Milhaljek & Klau (2004), who specified the empirical version of equation (13) in the following way:

$$\log(\frac{CPI}{CPI^*})_t = c + \beta_1 \log(\frac{E_t}{E_{t-1}}) + \beta_2 \left[(1-\alpha)_t \times \log(\frac{LP^T}{LP^{NT}})_t - (1-\alpha^*)_t \log(\frac{LP^{T*}}{LP^{NT*}})_t \right] + \varepsilon_t$$

. The correct representation of the theoretical relationship is however the one expressed in equation (14) , since the specification by M&K mix up levels of prices and productivity with the change in the exchage rate.. The M&K specification will therefore not be followed by this thesis.

have wage growth equalisation. Based on this fact it could be interesting to take differences in wage growth within sectors and between countries into account. In order to do this, recall the following first order conditions from the Balassa Samuelson model, presented in section 2:

$$w = \gamma(\frac{A^T(L^T)^\gamma(K^T)^{1-\gamma}}{L^T}) = \gamma\frac{Y^T}{L^T} \Leftrightarrow \gamma LP^T \tag{5'}$$

$$w = \mu\frac{P^{NT}}{P^T}(\frac{A^{NT}(L^{NT})^\mu(K^{NT})^{1-\mu}}{L^{NT}}) = \mu\frac{P^{NT}}{P^T}\frac{Y^{NT}}{L^{NT}} \Leftrightarrow \mu\frac{P^{NT}}{P^T}LP^{NT} \tag{6'}$$

Here real wage levels were assumed to be the same and equation (5') and (6') were equalized based on this assumption, substituting for wages.

Now this assumption will be relaxed while instead labour intensities are assumed equal. This yields the following specification of equation (5') and (6') above:

$$w^T = \gamma LP^T \tag{15}$$

$$w^{NT} = \gamma\frac{P^{NT}}{P^T}LP^{NT} \tag{16}$$

where $\mu = \gamma$. Solving (15) for γ and then substituting for γ in (16) gives the following expression:

$$w^{NT} = \frac{w^T}{LP^T}\frac{P^{NT}}{P^T}LP^{NT} \Leftrightarrow \frac{P^{NT}}{P^T} = \frac{w^{NT}}{w^T}\frac{LP^T}{LP^{NT}} \tag{17}$$

Since the real wage measures w^T and w^{NT} both have P^T as numeraire, the real wage fraction, $\frac{w^{NT}}{w^T}$, equals the nominal wage fraction $\frac{W^{NT}}{W^T}$. Hence, by log differentiating equation (17), I will get an alternative expression for the change in the relative price in the two sectors when non-uniform wage growth is taken into account:

$$\Delta p_t^{NT} - \Delta p_t^T = \Delta lp_t^T - \Delta lp_t^{NT} + \Delta\omega_t^{NT} - \Delta\omega_t^T \tag{18}$$

A similar equation will exist in the foreign country:

$$\Delta p_t^{NT^*} - \Delta p_t^{T^*} = \Delta lp_t^{T^*} - \Delta lp_t^{NT^*} + \Delta \omega_t^{NT^*} - \Delta \omega_t^{T^*} \qquad (18')$$

where ω^i, i = T, NT, denotes the logarithm of the nominal wage, hence $\Delta\omega^i$, i = T, NT, is the nominal wage growth in each sector. Inserting equation (18) and (18') in equation (10) and following the steps explained in detail in section 2, yields a new expression for the inflation differential, an alternative to the expression derived in equation (13), when the assumption on wage growth equalization is relaxed:

$$\Delta p_t - \Delta p_t^* = \Delta e_t + (1-\alpha)_t\left[\Delta lp_t^T - \Delta lp_t^{NT}\right] - (1-\alpha^*)_t\left[\Delta lp_t^{T^*} - \Delta lp_t^{NT^*}\right]$$

$$+ (1-\alpha)_t\left[\Delta \omega_t^{NT} - \Delta \omega_t^T\right] - (1-\alpha^*)\left[\Delta \omega_t^{NT^*} - \Delta \omega_t^{T^*}\right] \qquad (19)$$

The empirical version of equation (19) is then:

$$\log(\frac{CPI_t}{CPI_{t-1}}) - \log(\frac{CPI^*_t}{CPI^*_{t-1}}) = c + \beta_1 \log(\frac{E_t}{E_{t-1}}) + \beta_2 \begin{bmatrix} (1-\alpha)_t\left(\log(\frac{LP^T{}_t}{LP^T{}_{t-1}}) - \log(\frac{LP^{NT}{}_t}{LP^{NT}{}_{t-1}})\right) \\ -(1-\alpha^*)_t\left(\log(\frac{LP^{T^*}{}_t}{LP^{T^*}{}_{t-1}}) - \log(\frac{LP^{NT^*}{}_t}{LP^{NT^*}{}_{t-1}})\right) \end{bmatrix}$$

$$+\beta_3 \begin{bmatrix} (1-\alpha)_t\left(\log(\frac{W^{NT}{}_t}{W^{NT}{}_{t-1}}) - \log(\frac{W^T{}_t}{W^T{}_{t-1}})\right) \\ -(1-\alpha^*)_t\left(\log(\frac{W^{NT^*}{}_t}{W^{NT^*}{}_{t-1}}) - \log(\frac{W^{T^*}{}_t}{W^{T^*}{}_{t-1}})\right) \end{bmatrix} + v_t \qquad (20)$$

where W_t^i, i = T, NT, denotes the nominal wage level in each sector and v_t indicates the new error term (the other notation is similar to equation (14). If wage growth is equal in the two tradable and the non tradable sector, then the last term of equation (20) will be zero for the respective country and hence, have no effect on the inflation differential. Recall that no reliable wage data for Slovenia was available[18]. Equation (20) is the second testable equation.

There are now two equations, equation (14) and (20), that form the basis for the estimation of whether the observed differences in inflation between an EMU accession country and the Euro area can be explained by changes in the country's nominal exchange rate vis-à-vis the euro and/or by differences in relative productivity growth and/or, when equation (20) is estimated, by differences in relative wage growth.

If the Balassa-Samuelson effect prevails I should expect to find a positive relationship between the difference in inflation and the difference in relative productivity growth ($\beta_2 > 0$). Higher productivity growth in the tradable sector than in the non tradable sector leads to higher wages in the tradable sector, followed by higher wages in the non tradable sector due to the assumption of wage growth equalization[19]. Chart 6 (see section 4 below) indicates that even though wage equalization is not perfect, the wage growth seem to follow the same pattern, which supports the assumption that higher wage in one sector is followed by a higher, but not necessarily identical, wage increase in the other sector[20]. This non tradable wage increase will then pass through to higher non tradable prices, leading to a higher overall inflation in the accession country. The higher the relative productivity differential between the accession country and the Euro area, the larger is the expected effect on the inflation differential.

I would also expect there to be a positive relationship between the difference in inflation and the difference in relative wage growth ($\beta_3 > 0$) since a stronger wage growth in the non tradable sector will push the relative price of the non tradable good in terms of the tradable good upwards, leading to a higher overall inflation. If the wage growth is identical in the two sectors within one country, it will only affect the inflation differential through the labour productivity term, as explained above. If the accession country or the Euro area experience non uniform wage growth however, its possible effect on the inflation differential will be captured by the relative wage growth differential term. The higher this difference is in the

[18] According to Milhaljek & Klau (2004) Slovenia did not experience any non-uniform wage growth. Their article covers data up to 2002.
[19] Even though wage equalization is not necessarily perfect, chart 6 in section 4 indicates that nominal wage growth in the tradable sector is followed by nominal wage growth in the non tradable sector.
[20] This is not the case for Estonia where wages are negatively correlated with a correlation coefficient estimate of -0,13. This might be due to errors in the statistical data, as discussed in section 4 below.

accession country compared to the Euro area, the larger effect on the inflation differential can be expected.

In addition the model predicts a positive relationship between the difference in inflation and the change in the nominal exchange rate ($\beta_1 > 0$) since a depreciation of the home currency (E increases) makes domestic goods less expensive compared to foreign goods through a depreciation of the real exchange rate. For the law of one price to continue to hold the domestic price on tradables must increase to restore the balance, hence the overall inflation increases.

3.3 Data and variable description

The countries studied in this thesis are the four accession countries; Estonia, Latvia, Lithuania and the Slovak Republic in addition to Slovenia, a former accession country, now part of the Euro area. The countries are compared to the Euro area, which is represented by EMU12, meaning that the data for the monetary union are based on the members *prior* to the entrance of Slovenia. All time series are quarterly data from 1996, first quarter (1996:Q1) to 2007:Q1. This is a more recent data sample than what can be found in previous studies (data only up to 2002:Q4) and also more specified, since more effort has been put down to make all data consistent with each other (all series for all countries start in 1996:Q1 and they end in 2007:Q1). Taking recent year's development in Eastern Europe into account this thesis might therefore end up with fairly different results than earlier research.

Some series were only available seasonally adjusted and for the data in study to be perfectly comparable, the rest of the series were seasonally adjusted as well, using the algebraic code "movingavg (var, lag, lead)" in Givewin2, where three periods were lagged/led both ways. Due to the fact that moving average is used, the three first and the three last periods are lost. Below the variables used for the regression analysis of equation (14) and (20) will be described in some detail.

Labour productivity has been calculated using data for value added and employment. In the collection of the value added data this thesis follows the approach by Milhaljek & Klau (2004) by making use of the production approach value added data (expenditure approach not considered). All value added series are reported in constant prices. The employment data are in levels. The labour productivity variable is created by dividing value added on employment in each sector. All series were reported either as an aggregated category equal to the ones presented in section 2.1 or as separated series. In any case they were added together to one tradable and one non tradable sector based on the definition made in Table 2. Some trouble arose during the process of obtaining reliable data, see Appendix B for details.

As with the division into a tradable and a non tradable sector, how to find a presentable indicator for the relative price on the non tradable good in terms of the tradable good has been highly debated in the literature and no consensus has yet been found. A decomposition of the national consumer price index (CPI), using only the non-tradable part, is often used as an indicator of the non tradable price, while a different decomposition of the CPI has been used for the tradable price. Relative prices have also been defined as the ratio of the corresponding sectoral GDP deflators. Some studies cut short and apply CPI and the producer price index (PPI) as the non tradable and tradable price respectively. Égert et al (2002) have studied the question of which indices to use in detail and conclude that $\frac{services\_in\_CPI}{PPI}$ is the best measure of the relative price of non tradables in terms of tradables. Milhaljek & Klau (2004), who has been used as benchmark so far, follow the first example, applying a decomposition of the CPI.

Since the main focus in this thesis is to examine to what extent differences in productivity growth have an effect on the inflation differential between an accession country and the European monetary union, in the context of EMU membership, I have chosen to use the harmonized index of consumer price (HICP) for all countries in the analysis. Since only the international version of the Balassa-Samuelson effect is focused upon I do not find it necessary to pay that much attention to the relative price of the two sectors. The HICP's are consumer price indices that offer a comparable measure of inflation in the Euro area, the European Union in total and other countries, like the accession countries. These indices provide the official measure of consumer price inflation in the Euro area for the purpose of monetary policy. In the context of this thesis, however, the most important point is that when the accession countries' rate of inflation is considered in relation to fulfilling the Maastricht Inflation Criteria, it is the HICP that is examined more closely. Hence, it seems like a good idea to focus on explaining the HICP differences in the further analysis. There are many variants of the HICP and the one used in the analysis is the *HICP – All items*. This choice is made due to the fact that since December 1999 more or less all items included in the categories mentioned in section 2.1 above have been included in the HICP (See Official Journal of the European Communties (1998): Council Regulation (EC) No 1687/98 of 20 July 1998).

The left hand side variable of equation (14) and (20), illustrating the differences in inflation between the accession country and the European Monetary Union, is therefore, based on the above argumentation, assumed to be best described by the differences in the HICP and hence quarterly time series for the harmonized indices of consumer prices are collected for all countries as well as for the Euro area.

For all countries wage data were only reported as the total wage sum for each category. Nominal wage rates for each sector were then derived by adding wage sums for all categories in each sector, and then divide by total employment in the sector.

For Slovenia no reliable wage data were found. For the Euro area the four quarter change in wages were reported separately for each category and per employee. Total four quarter wage growth for each sector was then found by the following formula:

$$\frac{\sum(\text{"yearly change in wage, category X"} \bullet \text{"employment category X"})}{\text{Total employment in the sector category X belongs to}}$$

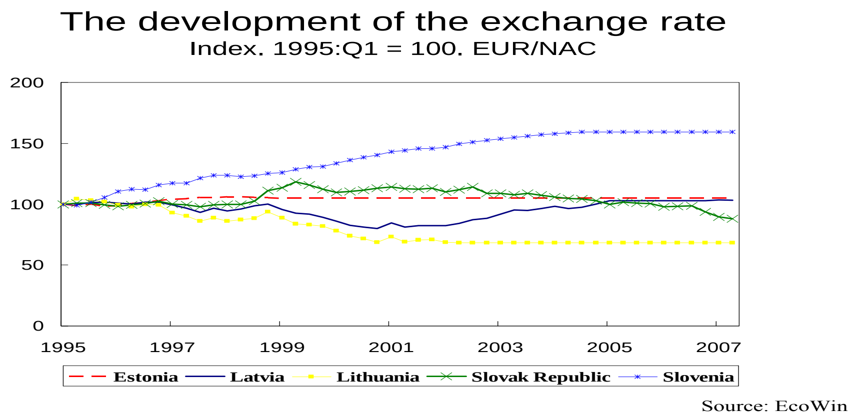
For the Slovak Republic the average monthly wage was reported for each single disaggregated category and the average monthly wage for the tradable and non tradable sector was then found in the following way:

$$\sum(\text{"monthly average wage, category X"} \bullet \text{"weight of employment category X in total employment"})$$

The wage data are given in national currency, current prices, when used in the analysis.

The exchange rate data are spot rates reported on quarterly basis. The unit is EUR/NAC which states how much must be paid in national currency (NAC) in order to get one euro. As can be seen in chart 1 the exchange rate has been fixed in Estonia and Lithuania the last 5-8 years. In Latvia and the Slovak Republic there has been little fluctuation as well, the former has been totally fixed since 2005. The Slovenian Tolar has depreciated steadily since 1995 until it became fixed towards the Euro in 2005 at 239,6 Tolar per Euro, a rate kept fixed after adoption 1 January 2007. The impact of having a fixed versus a fluctuating exchange rate in order to meet the Maastricht inflation criteria will be elaborated further in the concluding remarks.

CHART 1

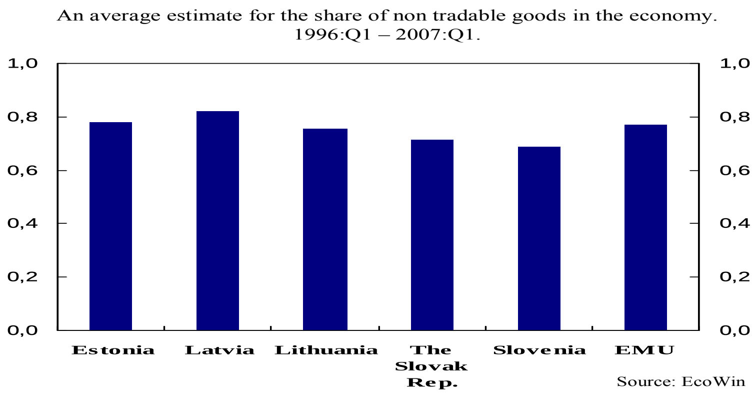


The remaining component, not already described, is the term $(1-\alpha)$. Alpha is the share of tradable goods in the economy. It is calculated by dividing the tradable value added data on total value added data. The share of non tradables in the economy, $(1-\alpha)$, follows. The reason why these shares are divided on the total value added, not leaving out the excluded categories, is that all the excluded categories are represented in the HICP and therefore belongs in the analysis (see discussion above). Recall that the only reason for the categories being excluded from the analysis is that the reported quarterly data for each sector were assumed to be unreliable and therefore a harmful rather than a helpful contribution to the labor productivity data. According to Milhaljek & Klau (2004) (M&K) most studies assume the shares of non-traded goods to be the same across countries. M&K improves the analysis by calculating country-specific shares and making them time varying. This thesis again follows the more thorough analysis by M&K to get the final results more reliable.

An average estimate for $(1-\alpha)$ for all countries and the Euro area is reported in chart 3. Only a quick glance is necessary to see that the estimates are quite large. While M&K report shares ranging from 54% to 60% for the accession countries and 76 % for the Euro area, the estimates for the share of non tradables in chart 2 are considerably higher for the accession countries (M&K do not consider the Baltic countries, which have even higher estimates than the Slovak Republic and Slovenia).

CHART 2

Average estimate of the share of non tradable goods in all countries and the Euro area

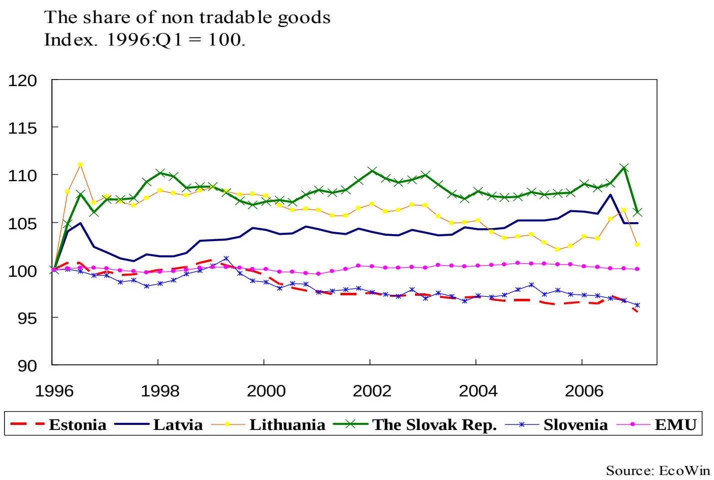


This disparity is chiefly a result of different sector division. It can be shown that by following the same sector division as M&K for the accession countries (based on this thesis' data sample), the estimates range from 62 to 69 percent, which is much lower. That the range still is a bit higher than M&K only exhibit a natural increase in the share of non tradables since the data used in this thesis are newer and therefore comprise the strong development of the non tradable sector in more recent years. Chart B.1 in Appendix B shows the economic growth in each sector for all countries.

As can be seen from the testable equations (14) and (20) in section 3.2, the effect of the difference in productivity growth and the effect of the difference in wage growth are multiplied by the term $(1-\alpha)$, i.e. the share of non-tradable goods. This share is allowed to vary over time and as can be seen in Chart 3, the share fluctuates quite a lot over the sample period. The correlation between the share and the difference in productivity growth turned out to be substantial for all countries, so to avoid that the short run fluctuations in the share of non-tradable goods disturb the estimate of the coefficient of the difference in productivity growth (and also the difference in wage growth), I use a moving average of $(1-\alpha)$ over seven quarters.

CHART 3

The share of non tradable goods in all countries and the Euro area



4. Development over time

This thesis seeks to investigate whether a Balassa-Samuelson effect is present in six EMU accession countries; that is whether the inflation differences between the accession countries and the Euro area can be explained by differences in relative productivity growth, changes in the nominal exchange rate vis-à-vis the euro and also by differences in relative wage growth. In that respect two testable equations, equation (14) and (20) above, have been derived. Before moving on to the estimation of the equations, however, it is useful to see how the different components of the equations have developed over time.

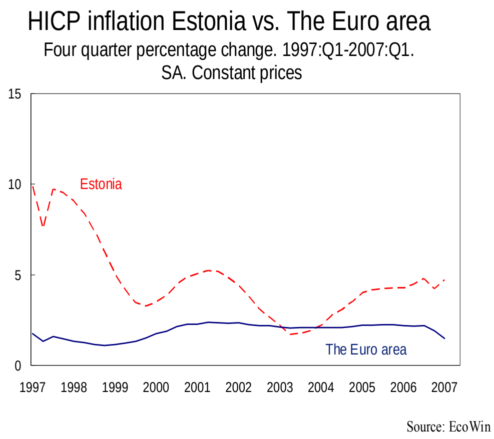
Chart 4 and 5 below show the four quarter percentage change in prices and labour productivity respectively for all countries and the Euro area. In chart 4 the development of HICP inflation rate in the EMU accession countries versus the EMU HICP inflation rate is illustrated and we see that for the whole sample period, the HICP inflation is higher in all accession countries than in the monetary union. This fact lays the foundations for this thesis and it is this difference I seek to explain. If we take a closer look at the Slovenian panel we see that inflation has had a steady convergence down towards the EMU inflation rate since 2001 and Slovenia was hence rewarded in January with EMU accession. As mentioned in section 1, Estonia and Lithuania missed out on EMU membership in 2006 due to failure in reaching the Inflation Criteria. As can be seen in Chart 4, both countries have drifted away from the EMU inflation rate since then, the Lithuanian inflation was recently described as "out of control" by Lars Christensen, chief economist at Danske Bank[21]. The Slovak Republic seems to be on the right way, the inflation rate has been converging steadily towards the EMU rate since 2004 and, according to the Wall Street Journal, the Slovakians hope to get the nod from the EMU-countries next year, having inflation, as well as government spending, under control. In Latvia, on the other hand, the inflation rate has been diverging from the EMU rate since 2003.

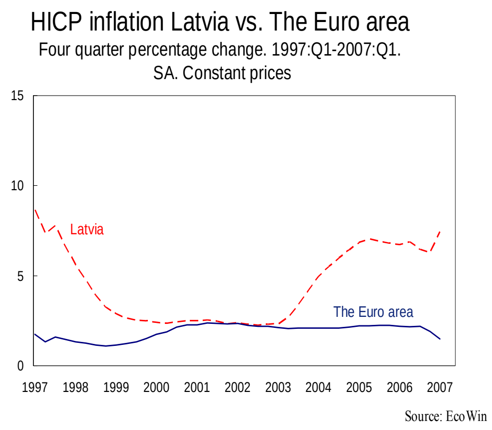
Turning to chart 5 we see that all countries have a higher labour productivity growth in the tradable sector, than in the non tradable sector on average, which is a good starting point for

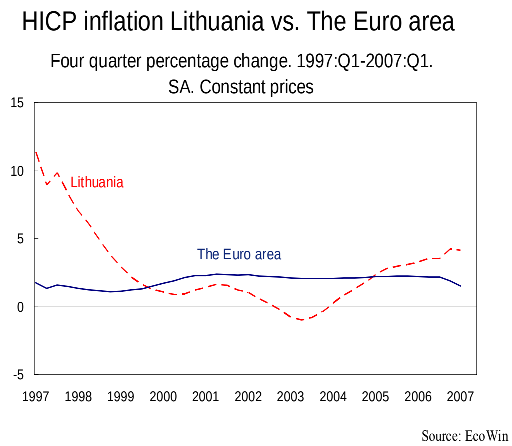
[21] The Wall Street Journal, October 15, 2007 at page 11.

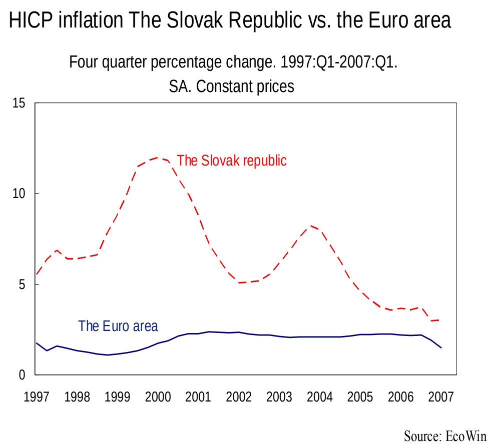
CHART 4

Four quarter percentage change in the HICP (Harmonized Index of Consumer Prices).









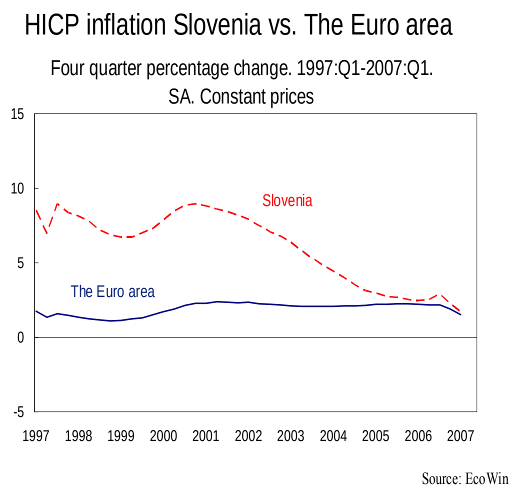
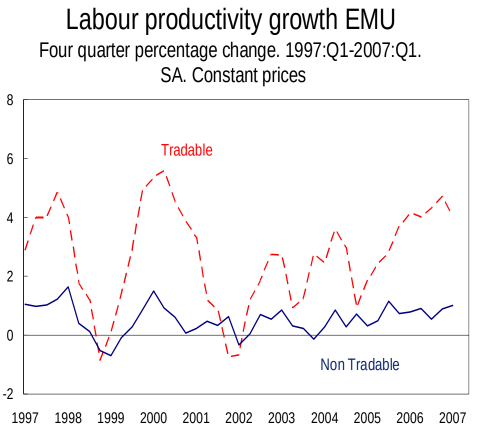
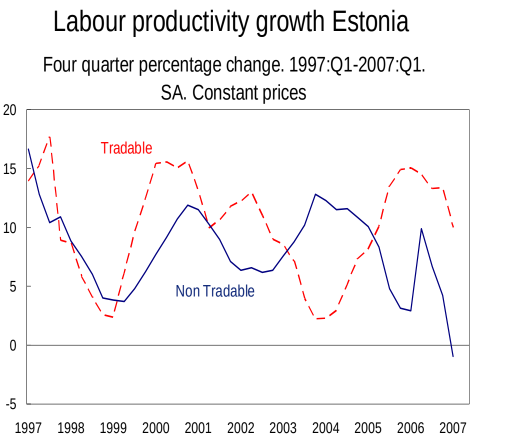


CHART 5

Four quarter percentage change in labour productivity.



Source: EcoWin



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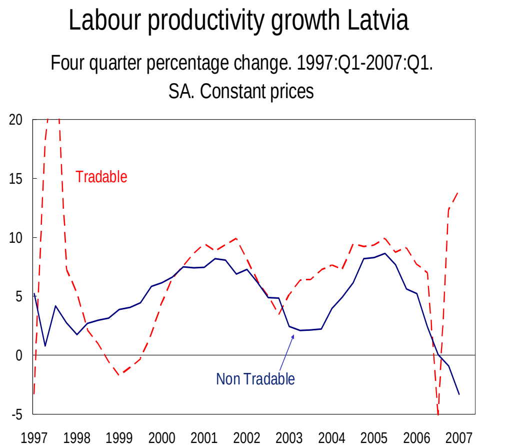

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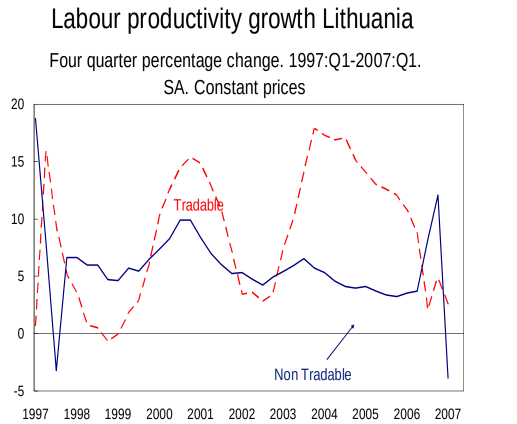

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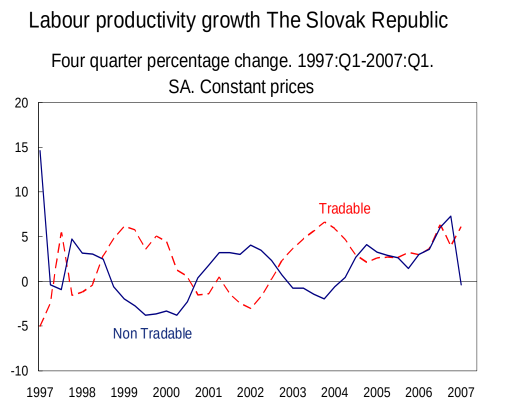

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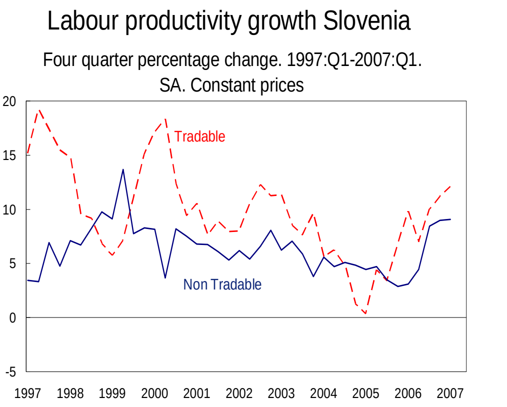


Source: EcoWin

the search of a possible Balassa-Samuelson effect, since, according to theory, it should imply higher non-tradable prices[22]. It is worth mentioning that Slovenia is no exception in this case; labour productivity growth has been higher in the tradable sector, but still it has been able to reach the Maastricht Inflation Criteria by bringing inflation steadily down to the EMU rate. Recall that it is not the relative labour productivity growth in each country that matters for the inflation differential, but the relative labour productivity growth *differential* between the accession country and the Euro area.

Chart 6 below reports the development in wage growth in all countries and the Euro area. We see that wage growth equalization is the case for Latvia, the Slovak Republic and the Euro area. The Estonian and Lithuanian wage data on the other hand, are a bit droll. There is no evidence of wage growth equalization; in fact it can look like nominal wages in the two sectors are negatively correlated. Computing a correlation matrix on the two confirms this for Estonia with a correlation coefficient for tradable and non tradable wage growth at -0,13. For Lithuania, the correlation coefficient is 0,09. Both estimates suggest a very low degree of correlation which is a somewhat odd result. It might descend from errors in the data and should be examined more closely in later studies.

Table 4 in the next section presents the variables used in the estimation process; the inflation differential, the change in the nominal exchange rate, the relative labour productivity growth differential and the relative nominal wage differential. Through out this analysis the growth is calculated as the four quarter change, i.e. from quarter *i* in year t to quarter *i* in year t-1.

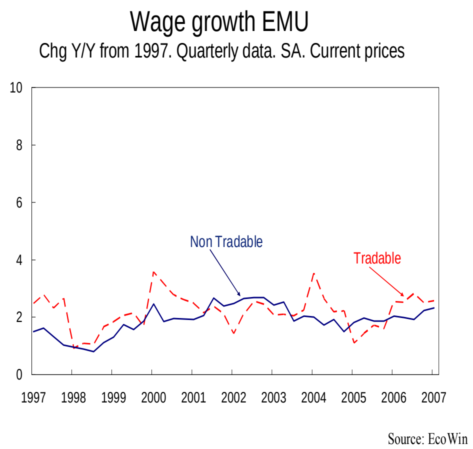
Chart 7 below shows the development of these variables and is therefore a small aperitif of what we might find when estimating the relationship. The first issue worth noticing when studying the panels in chart 7 is the difference between the Slovakian and Slovenian panel and the Baltic panels. In the three latter, there are much more volatility in the series than in the two former. For both Latvia and Lithuania the volatility in the series have become smaller in recent years which indicates that the economic activity in the countries now are more similar to the activity in the Euro area, but in the Estonian case the volatility in the series persist and even become worse around 2004.

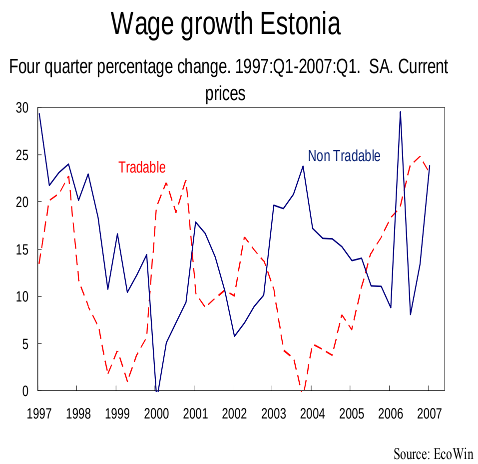
Above I have suggested that there might be something wrong with the Estonian wage data.

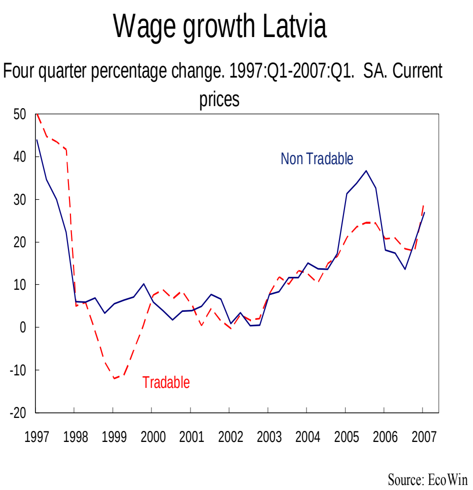
[22] Referred to earlier as the Baumol-Bowen effect.

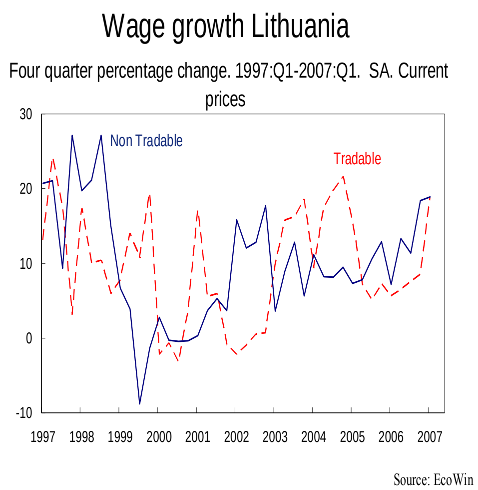
CHART 6

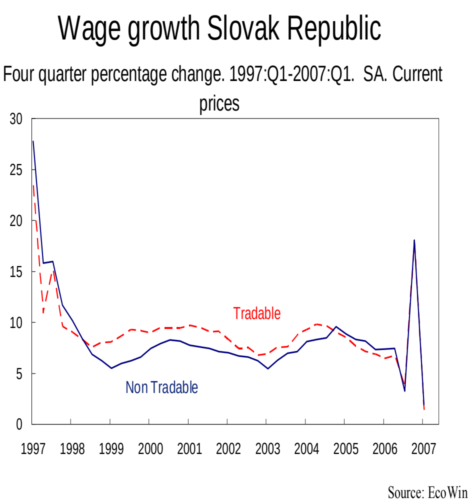
Yearly wage growth in the tradable and non tradable sector.







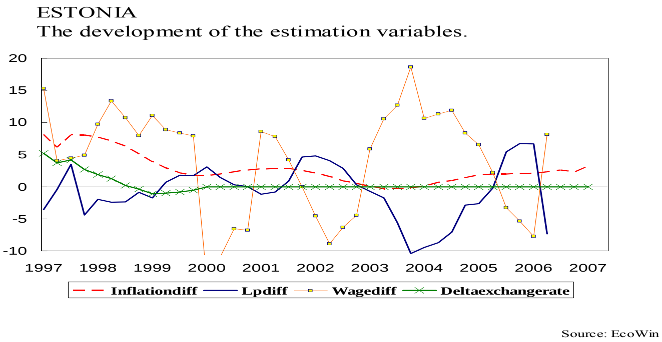


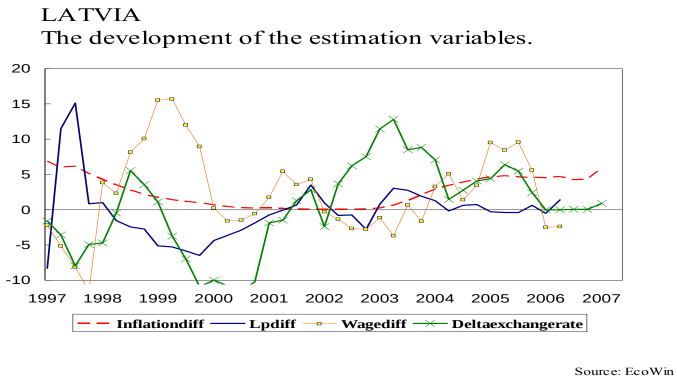


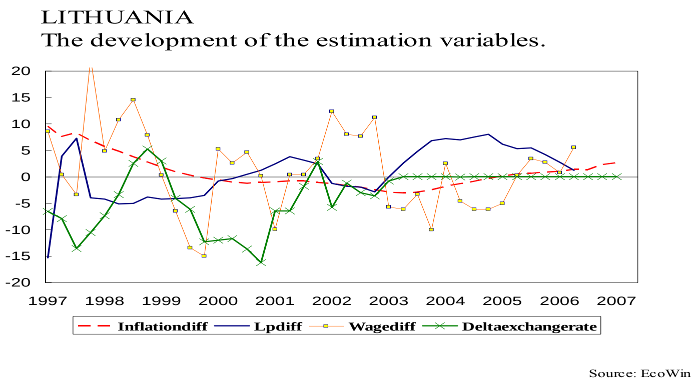
Reliable wage data for Slovenia was not available.

CHART 7

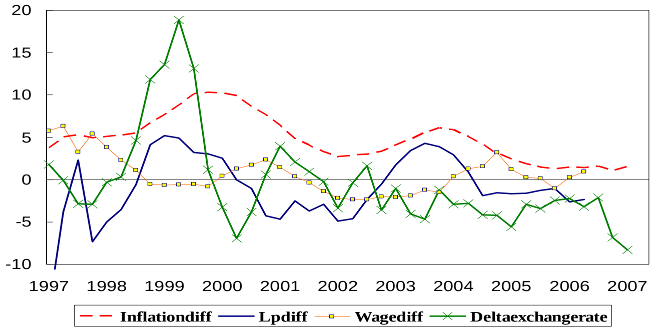
The development of the variables in equation (14) and (20). The notation is the same as the one used in table 4 in section 5.





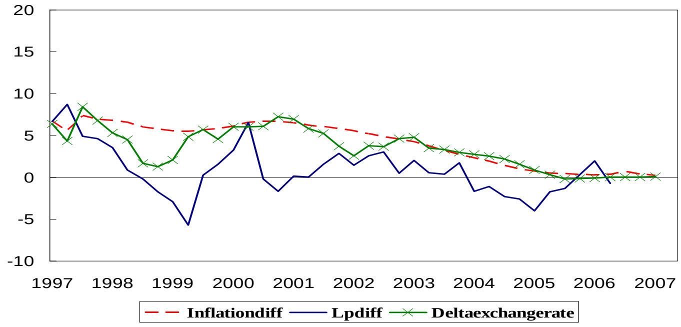


THE SLOVAK REPUBLIC
The development of the estimation variables.



Source: EcoWin

SLOVENIA
The development of the estimation variables.



Source: EcoWin

The gap between tradable and non tradable wage growth is particularly large around 2004. Turning to chart 5, we see that non tradable labour productivity growth is considerably higher than tradable in the same period, a result that deviates from the development in the rest of the period for Estonia, and for all the other countries in general. This implies that there are possible errors in the reported Estonian data around 2004. It might be that the employment data are too high in the tradable sector, or too low in the non tradable sector, such that the difference in labour productivity growth differential becomes too low and/or the wage growth differential too high.   This uncertainty in the data weakens the empirical results in this thesis, for Estonia. As will come clear in section 5.3, the only variable that has a significant effect on the inflation differential is the changes in the nominal exchange rate. Without data errors however, the Estonian results might have been different, and examining this further could be an interesting approach in later studies.

For all panels, but the Slovakian in chart 7 there seem to be a pattern in the data that supports the hypothesis in section 3.2 stating that a *positive* relative productivity growth differential, a *positive* change in the nominal exchange rate (i.e. depreciation) and/or a *positive* relative wage growth differential will lead to an increase in the inflation differential. When the explanatory variables are positive, the inflation differential also appears to be positive, and vice versa. It also seems like all explanatory variables have some sort of explanatory power for all countries except Slovenia. Since Slovenia is the only country so far to adopt the euro, it is worth taking a moment to study their performance. It seems to be the case that changes in the exchange rate explains more of the changes in the inflation differential than the productivity growth differential. Inflation persisted at a high level, even when the productivity differential fell in 2000, and first became smaller in step with the declining depreciation. Since 2005 there has hardly been any movement in the series, indicating that Slovenia had everything under control and indeed was ready to adopt the euro.

The Slovak republic is supposed to be the next in line to enter the EMU and the declining volatility of the series presented in chart 7 is a positive sign. Low volatility in the series over a longer period means a lower probability of asymmetric shocks in the economy since the country seems to be able to keep the economy under control. It also means that the country has become more similar to the economy of the European Monetary Union. Both aspects are crucial for EMU membership. The correlation between the explanatory variables and the inflation differential, however, looks puzzling. The explanatory variables are more negative, than positive over the sample period, but the inflation differential is only positive. The empirical analysis give favorable conditions for this puzzle by suggesting a negative sign on the Balassa-Samuelson estimate.

Table 3 provides a survey of average values of all the components in the testable equations. It shows percentage contribution of different determinants of the inflation differential for each accession country. The upper panel shows the average four quarter percentage change over the whole sample period, while the lower panel concentrates on the last three years. We see that for Slovenia the average inflation differential over the whole sample period seem to be explained almost entirely from depreciation of the exchange rate, as predicted above. In the more recent sample period, after the devaluation process has declined, the inflation differential has declined as well.

The upper panel indicates that the relative wage growth differential drives inflation in Estonia and Latvia over the sample period. This still holds for Estonia in the lower panel (recall that there might be data errors in the case of Estonia around 2004), while in Latvia the positive contribution of the wage growth differential has been accompanied by a strong depreciation of the exchange rate taking place from 2002 to 2006 and a much higher relative productivity differential than the overall average. This has almost doubled the inflation differential, leading Latvia into the dilemma of enjoying the fast development or cooling it down in order to reach the Maastricht Criteria. Prime Minister Mr. Aigars Kalvitis confirms this dilemma when he warns not to cool down too much since Latvia needs to catch up to Europe, but at the same time says the country is very interested to join the euro as soon as possible[23].

Recall the testable equations to easier understand the table below:

$$\log\left(\frac{CPI_t}{CPI_{t-1}}\right) - \log\left(\frac{CPI^*_t}{CPI^*_{t-1}}\right) = c + \beta_1 \log\left(\frac{E_t}{E_{t-1}}\right) + \beta_2 \begin{bmatrix} (1-\alpha)_t \left(\log\left(\frac{LP^T_t}{LP^T_{t-1}}\right) - \log\left(\frac{LP^{NT}_t}{LP^{NT}_{t-1}}\right) \right) \\ -(1-\alpha^*)_t \left(\log\left(\frac{LP^{T^*}_t}{LP^{T^*}_{t-1}}\right) - \log\left(\frac{LP^{NT^*}_t}{LP^{NT^*}_{t-1}}\right) \right) \end{bmatrix} + \varepsilon_t \tag{14}$$

$$\begin{aligned} \log\left(\frac{CPI_t}{CPI_{t-1}}\right) - \log\left(\frac{CPI^*_t}{CPI^*_{t-1}}\right) = c + \beta_1 \log\left(\frac{E_t}{E_{t-1}}\right) + \beta_2 \begin{bmatrix} (1-\alpha)_t \left(\log\left(\frac{LP^T_t}{LP^T_{t-1}}\right) - \log\left(\frac{LP^{NT}_t}{LP^{NT}_{t-1}}\right) \right) \\ -(1-\alpha^*)_t \left(\log\left(\frac{LP^{T^*}_t}{LP^{T^*}_{t-1}}\right) - \log\left(\frac{LP^{NT^*}_t}{LP^{NT^*}_{t-1}}\right) \right) \end{bmatrix} \\ + \beta_3 \begin{bmatrix} (1-\alpha)_t \left(\log\left(\frac{W^{NT}_t}{W^{NT}_{t-1}}\right) - \log\left(\frac{W^T_t}{W^T_{t-1}}\right) \right) \\ -(1-\alpha^*)_t \left(\log\left(\frac{W^{NT^*}_t}{W^{NT^*}_{t-1}}\right) - \log\left(\frac{W^{T^*}_t}{W^{T^*}_{t-1}}\right) \right) \end{bmatrix} + v_t \end{aligned} \tag{20}$$

[23] The Wall Street Journal, October 15, 2007, at page 11.

Table 3 Four quarters growth averages of the different components of equation (14) and (20).

Country	Inflation differential vis-à-vis the Euro area [a]	Change in the nominal Exchange rate vis-à-vis euro [b]	Share of non tradables $(1-\alpha)$	Productivity growth [c] Tr.	Productivity growth [c] Non tr.	Wage growth [d] Tr.	Wage growth [d] Non tr.	Contribution of productivity growth differential to inflation differential [e]	Contribution of wage growth differential to inflation differential [f]	Total contribution of explanatory variables to inflation differential [g]
Average of entire sample period 1996-2007										
ESTONIA	2,792	0,373	0,778	10,051	8,399	12,043	15,057	-0,361	2,585	2,597
LATVIA	2,576	0,369	0,823	6,664	4,617	12,175	13,553	0,039	1,374	1,782
LITHUANIA	0,784	-3,425	0,755	8,610	5,666	9,441	10,015	0,577	0,673	-2,175
SLOVAK REPUBLIC	4,837	-0,373	0,715	2,225	1,431	8,931	8,450	-1,078	-0,104	-1,555
SLOVENIA	4,13	3,477	0,686	9,783	6,360	NA	**NA**	0,702	NA	4,179
EURO AREA	1,91 [h]	---	0,771	2,679	0,544	2,201	1,890	---	---	---
Average of the most recent sample period 2004-2007										
ESTONIA	1,792	-0,002	0,767	10,043	8,184	13,738	15,237	-0,542	1,34	0,796
LATVIA	4,378	2,695	0,835	8,160	4,386	19,591	22,342	1,185	2,547	6,427
LITHUANIA	0,505	0,005	0,739	11,295	3,980	11,550	11,141	3,438	-0,052	3,391
SLOVAK REPUBLIC	2,484	-3,931	0,714	3,833	2,806	7,988	8,103	-1,233	0,332	-4,832
SLOVENIA	0,804	0,772	0,681	6,380	5,371	NA	**NA**	-1,281	NA	-0,509
EURO AREA	2,102 [h]	**NA**	0,773	3,234	0,691	2,257	1,938	---	---	---

[a] Defined as $\left[\log\left(\frac{CPI^{i}_{t}}{CPI^{i}_{t-1}}\right) - \log\left(\frac{CPI^{i}_{t}{}^{*}}{CPI^{i}_{t-1}{}^{*}}\right)\right]$ for each country vis-à-vis the Euro area, based on the yearly averages (in percentage points and with t denoting all quarters from 1997:Q1 – 2007:Q1 and t-1 indicating one year earlier than quarter t. i = 1,2,3,4 and indicates hence quarter i each year. Same explanation for all similar notation below).

[b] Defined as yearly average of $\log\left(\frac{E^{i}_{t}}{E^{i}_{t-1}}\right)$ for each country

[c] Defined as yearly average of $\log(\frac{LP^{i^T}{}_t}{LP^{i^T}{}_{t-1}})\, and\, \log(\frac{LP^{i^{NT}}{}_t}{LP^{i^{NT}}{}_{t-1}})$ respectively for each country and the Euro area.

[d] Defined as yearly average of $\log(\frac{W^{i^T}{}_t}{W^{i^T}{}_{t-1}})\, and\, \log(\frac{W^{i^{NT}}{}_t}{W^{i^{NT}}{}_{t-1}})$ respectively for each country and the Euro area.

[e] Defined as $\left[(1-\alpha)\times\left(\log(\frac{LP^{i^T}{}_t}{LP^{i^T}{}_{t-1}})-\log(\frac{LP^{i^{NT}}{}_t}{LP^{i^{NT}}{}_{t-1}}\right)-(1-\alpha^*)\left(\log(\frac{LP^{i^{T*}}{}_t}{LP^{i^{T*}}{}_{t-1}}-\log(\frac{LP^{i^{NT*}}{}_t}{LP^{i^{NT*}}{}_{t-1}}\right)\right]$ for each country vis-à-vis the Euro area, based on the yearly averages.

[f] Defined as $\left[(1-\alpha)\times\left(\log(\frac{W^{i^{NT}}{}_t}{W^{i^{NT}}{}_{t-1}})-\log(\frac{W^{i^T}{}_t}{W^{i^T}{}_{t-1}}\right)-(1-\alpha^*)\left(\log(\frac{W^{i^{NT*}}{}_t}{W^{i^{NT*}}{}_{t-1}}-\log(\frac{W^{i^{T*}}{}_t}{W^{i^{T*}}{}_{t-1}}\right)\right]$ for each country vis-à-vis the Euro area, based on the yearly averages.

[g] Calculated as the sum of the columns *b*, *e* and *f*.

[h] The average inflation rate. Defined as yearly average of $\log(\frac{CPI^i{}_t}{CPI^i{}_{t-1}})$.

In Lithuania the strong appreciation of the exchange rate until it became fixed in 2003 has contributed highly to the low inflation rate and is the main reason for why the inflation differential was negative from 2000-2005 (see chart 4 above). In the more recent panel we see that the inflation differential is still low while the labour productivity differential is almost six times the overall average, a result that not exactly supports the existence of a Balassa-Samuelson effect in terms of relative productivity growth differentials in Lithuania. On the other hand, Lithuanian inflation is described as “out of control” at present, which might imply that the higher productivity differential has a lagged effect on the inflation differential, but that is only speculation. The empirical results presented in section 5.2 supports the latter hypothesis.

For the Slovak Republic the inflation differential has become smaller, but is strongly positive over the sample period, while the total contribution of the explanatory variables is negative. This is a somewhat puzzling result suggesting that there might be other factors affecting inflation than the ones emphasized in this thesis.

5. Empirical results

Since this thesis only makes use of single dynamic equations, time series techniques are employed. Table 4 gives a description of the variables used in the estimation process. The algebraic codes from creating the variables are reported in Appendix B. In table 4 only testable equation (20) is shown, since the other testable equation, equation (14), is identical minus the wage term. Recall that the asterisk always indicates the Euro area.

Table 4 Variable description

Equation(20)

$$\log(\frac{CPI_t}{CPI_{t-1}})-\log(\frac{CPI^*_t}{CPI^*_{t-1}})=c+\beta_1\log(\frac{E_t}{E_{t-1}})+\beta_2\left[\begin{array}{l}(1-\alpha)_t\left(\log(\frac{LP^T_t}{LP^T_{t-1}})-\log(\frac{LP^{NT}_t}{LP^{NT}_{t-1}})\right)\\-(1-\alpha^*)_t\left(\log(\frac{LP^{T^*}_t}{LP^{T^*}_{t-1}})-\log(\frac{LP^{NT^*}_t}{LP^{NT^*}_{t-1}})\right)\end{array}\right]+\beta_3\left[\begin{array}{l}(1-\alpha)_t\left(\log(\frac{W^{NT}_t}{W^{NT}_{t-1}})-\log(\frac{W^T_t}{W^T_{t-1}})\right)\\-(1-\alpha^*)_t\left(\log(\frac{W^{NT^*}_t}{W^{NT^*}_{t-1}})-\log(\frac{W^{T^*}_t}{W^{T^*}_{t-1}})\right)\end{array}\right]+v_t$$

Variable name The X-ending on all variables are substituted with the abbreviation of each country-name.	**Reference for variable name**
Inflationdiff_X	$\log(\frac{CPI_t}{CPI_{t-1}})-\log(\frac{CPI^*_t}{CPI^*_{t-1}})$
LPdiff_X	$\left[(1-\alpha)_t\left(\log(\frac{LP^T_t}{LP^T_{t-1}})-\log(\frac{LP^{NT}_t}{LP^{NT}_{t-1}})\right)-(1-\alpha^*)_t\left(\log(\frac{LP^{T^*}_t}{LP^{T^*}_{t-1}})-\log(\frac{LP^{NT^*}_t}{LP^{NT^*}_{t-1}})\right)\right]$
Wagediff_X	$\left[(1-\alpha)_t\left(\log(\frac{W^{NT}_t}{W^{NT}_{t-1}})-\log(\frac{W^T_t}{W^T_{t-1}})\right)-(1-\alpha^*)_t\left(\log(\frac{W^{NT^*}_t}{W^{NT^*}_{t-1}})-\log(\frac{W^{T^*}_t}{W^{T^*}_{t-1}})\right)\right]$
Deltaexchangerate_X	$\log(\frac{E_t}{E_{t-1}})$

When running regressions all indices are first rescaled, making 1996:Q1 equal to 100. Then growth is calculated by the following formula:

$$\left(\frac{x^i{}_t-x^i{}_{t-1}}{x^i{}_{t-1}}\right)*100$$

where the t denotes all quarters from 1997:Q1 to 2007:Q1, i = 1-4, denotes which quarter each year and the "1" denotes one year, so that the expression gives the four quarter percentage change in the variable, reported quarterly.

5.1 Unit root tests

Variables like prices, productivity and wages are believed to grow over time, and therefore to be non stationary (as for example being a random walk). Most such variables however, are I(1) processes[24], that is they must be differenced once to become stationary (i.e. they are integrated of degree one). In this analysis the variables are first differences; in fact they denote the difference between two first differenced terms, so it is reasonable to expect the variables to be stationary. This belief is supported by performing an Augmented Dickey Fuller (ADF) unit root test on all variables used in the analysis. The results of the test are reported in table 5 below and a short description of the test is given in Appendix C. The numbers in brackets denote the lag order. The maximum lag order is set to four, The null hypothesis of the ADF test is non-stationarity and, as is evident from the table, the test rejects this hypothesis for almost all series. The three exceptions are the change in the Slovenian nominal exchange rate, the Slovakian inflation differential and the Latvian inflation differential. Only the latter is a source of anxiety, since the two former are very close to the critical 10 % value and therefore can be assumed stationary. Since the variables are based on first differences, an indication of a non stationary inflation differential is the same as indicating that the difference in price levels between the accession country and the Euro area is integrated of degree two. Designating a variable to be an I(2) process do put very strict restrictions on the regression coefficients and it is not necessary true that the variable actually *is* integrated of degree two. The Dickey-Fuller test is assumed to have quite low power such that there is a possibility to not reject the hypothesis of non-stationarity even if the series in fact are stationary. In this case I choose to presume that also the Latvian inflation differential is stationary since the other variables all seem to be, but keep in mind that it might as well not be, and in that case lead to somewhat spurious results.

[24] According to Kennedy, P. (2003) variables are seldom integrated of order greater than two, and are usually integrated of degree one (i.e. I(1).

Table 5 Results Augmented Dickey-Fuller unit root test 1998:Q2-2007:Q1 [a]

(Test for stationarity of variables. Null hypothesis = Non stationarity)

Variable	Critical values
Inflationdiff_X	
Estonia	-3,887[0]***
Latvia	-0,626[0]
Lithuania	-3,049[0]***
Slovak Republic	-1,342[1]
Slovenia	-3,169[0]***
LPdiff_X	
Estonia	-2,381[0]**
Latvia	-2,183[0]**
Lithuania	-2,541[1]**
Slovak Republic	-2,862[1]***
Slovenia	-3,472[0]***
Wagediff_X	
Estonia	-2,728[0]**
Latvia	-3,350[2]***
Lithuania	-3,183[0]***
Slovak Republic	-2,175[0]**
Deltaexchangerate_X	
Estonia	-5,051[0]***
Latvia	-2,006[1]**
Lithuania	-2,748[3]***
Slovak Republic	-2,784[2]***
Slovenia	-1,371[0]

[a] The stars (*) denotes the significance level of the DF critical t-values. (10% = -1,6 = *, 5% = -1,95 = **, 1% = -2,66 = ***).

5.2 Results

Now that the variables in the analysis are assumed to be stationary, valid results can be expected by running OLS regression on the testable equations (14) and (20). The results are reported in table 6.1 and 6.2.

Table 6.1 Result from OLS regression of equation (14):

$$\log\left(\frac{CPI_t}{CPI_{t-1}}\right) - \log\left(\frac{CPI^*_t}{CPI^*_{t-1}}\right) = c + \beta_1 \log\left(\frac{E_t}{E_{t-1}}\right) + \beta_2 \left[\begin{array}{l} (1-\alpha)_t \left(\log\left(\frac{LP^T{}_t}{LP^T{}_{t-1}}\right) - \log\left(\frac{LP^{NT}{}_t}{LP^{NT}{}_{t-1}}\right) \right) \\ -(1-\alpha^*)_t \left(\log\left(\frac{LP^{T^*}_t}{LP^{T^*}_{t-1}}\right) - \log\left(\frac{LP^{NT^*}_t}{LP^{NT^*}_{t-1}}\right) \right) \end{array} \right] + \varepsilon_t$$

Country Sample period: 1997:Q1-2007:Q1	$\hat{\beta}_1$	$\hat{\beta}_2$	R^2	DW
Estonia	**1,3507** (6,73)**	**0,0731** (1,21)	**0,55**	**0,17**
Latvia	**-0,1949** (-2,61)**	**0,1792** (1,88)*	**0,19**	**0,20**
Lithuania	**-0,0949** (-1,07)	**-0,2221** (-2,47)**	**0,18**	**0,16**
The Slovak Republik	**0,1827** (2.78)**	**0,2152** (2,29)**	**0,31**	**0,21**
Slovenia	**0,852** (8,94)**	**0,0625** (0,79)	**0,75**	**0,42**

[a] The values in brackets are t-values. One asterisk (*) indicates significant at 10 % level, i.e. t-value above 1,7. Two asterisks (**) indicate significant at 5 % level, i.e. t-value above 2,05.

Table 6.2 Result from OLS regression of equation (20):

$$\log(\frac{CPI_t}{CPI_{t-1}})-\log(\frac{CPI^*_t}{CPI^*_{t-1}})=c+\beta_1\log(\frac{E_t}{E_{t-1}})+\beta_2\left[\begin{array}{l}(1-\alpha)_t\left(\log(\frac{LP^T{}_t}{LP^T{}_{t-1}})-\log(\frac{LP^{NT}{}_t}{LP^{NT}{}_{t-1}})\right)\\-(1-\alpha^*)_t\left(\log(\frac{LP^{T^*}_t}{LP^{T^*}_{t-1}})-\log(\frac{LP^{NT^*}_t}{LP^{NT^*}_{t-1}})\right)\end{array}\right]$$

$$+\beta_3\left[\begin{array}{l}(1-\alpha)_t\left(\log(\frac{W^{NT}{}_t}{W^{NT}{}_{t-1}})-\log(\frac{W^T{}_t}{W^T{}_{t-1}})\right)\\-(1-\alpha^*)_t\left(\log(\frac{W^{NT^*}_t}{W^{NT^*}_{t-1}})-\log(\frac{W^{T^*}_t}{W^{T^*}_{t-1}})\right)\end{array}\right]+v_t$$

Country Sample period: 1997:Q1-2007:Q1	$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\beta}_3$	R^2	DW
Estonia	**1,328** (6,66)**	**0,151** (1,79)*	**0,059** (1,32)	**0,57**	**0,22**
Latvia	**-0,181** (-2,32)**	**0,147** (1,38)	**-0,06** (-0,689)	**0,21**	**0,17**
Lithuania	**-0,11** (-1,22)	**-0,178** (-1,79)*	**0,066** (1,00)	**0,20**	**0,2**
The Slovak Republik	**0,1836** (2.68)**	**0,218** (2,01)*	**0,0195** (0,06)	**0,31**	**0,21**
Slovenia	**NA**	**NA**	**NA**	**NA**	**NA**

[a] The values in brackets are t-values. One asterisk (*) indicates significant at 10 % level, i.e. t-value above 1,7. Two asterisks (**) indicate significant at 5 % level, i.e. t-value above 2,05.

If we for a moment only look at the coefficient values in table 6.1 and 6.2, they confirm the predicted positive sign on most of the significant regression coefficients estimates. The DW statistics however, (reported in the last column), point toward autocorrelation in the residuals. The critical values of the Durbin-Watson (DW) tests are (dL, dU) = (1.34 , 1.66) for equation (14), since there are 41 observations and three right hand side variables (the constant, the change in the nominal exchange rate and the relative labor productivity growth differential), and (dL, dU) = (1.29 , 1.72) for equation (20), including one extra explanatory variable (the relative wage growth differential)[25]. The DW statistics reported in table 6.1 and 6.2 are all over very low, suggesting positive autocorrelation in the residuals.

Autocorrelation in the residuals indicate that there exist some systematic properties of the endogenous variable that the model does not catch. If this is owing to an omitted variable, not correlated with the included ones, then the parameter bias does not have to be that big. Since the DW-statistics increases for some of the countries when an additional variable is included in equation (20) (shown in table 6.2), it seems reasonable to believe that some part of the low DW statistics is due to omitted variables. This is reinforced by the relative low estimate of R^2. That we don't see a considerable increase in the DW statistics may be due to the fact that the additional variable in equation (20); the relative wage growth differential, does not lead to a much higher R^2, which implies that it is not a variable of great significance. For the Slovak Republic the R^2 stays the same when the wage variable is added, which agrees with the statement made in section 4; Since both the Slovak Republic and the Euro area experience wage growth equalization between the sectors, a relative wage growth differential variable should not have any effect on the inflation differential.

An LM-test performed on the equation however, do reject the hypothesis of non auto correlation, meaning that even if some of the low DW statistics may be due to omitted variables, auto correlation in the residuals are definitely present. Positive autocorrelation, as in this case, means that the t-values are overvalued.

To deal with the auto correlation in the residuals the endogenous variable is included on the right hand side of the equations, lagged one period. To simplify notation the variable names created in table 4 in the beginning of this section will be used in the further analysis and hence substitute for the variables in equation (14) and (20) in the following way:

[25] Critical DW values are from Greene, W. (2003)

For equation (14):

$$\left(Inflationdiff\_X\right)_t = c + \beta_1\left(deltaexchangerate\_X\right)_t + \beta_2\left(LPdiff\_X\right)_t + \varepsilon_t \qquad (14)$$

For equation (20):

$$\left(Inflationdiff\_X\right)_t = c + \beta_1\left(deltaexchangerate\_X\right)_t + \beta_2\left(LPdiff\_X\right)_t$$

$$+ \beta_3\left(Wagediff\_X\right)_t + v_t \qquad (20)$$

where “X” indicates the country in study.
Including a lagged endogenous variable on the right hand side then yields the following two testable equations:

$$\left(Inflationdiff\_X\right)_t = c + \beta_0\left(Inflationdiff\_X\right)_{t-1} + \beta_1\left(deltaexchangerate\_X\right)_t$$

$$+ \beta_2\left(LPdiff\_X\right)_t + \mu_t \qquad (21)$$

$$\left(Inflationdiff\_X\right)_t = c + \beta_0\left(Inflationdiff\_X\right)_{t-1} + \beta_1\left(deltaexchangerate\_X\right)_t$$

$$+ \beta_2\left(LPdiff\_X\right)_t + \beta_3(Wagediff\_X)_{t-1} + \tau_t \qquad (22)$$

The results are reported in table 7.1 and table 7.2. The Durbin Watson (DW) statistics is not reported since the DW test is no longer valid with a lagged endogenous variable on the right hand side. An LM test run for all countries in PcGive[26] on the other hand, is valid and rejects the null hypothesis of autocorrelation in the residuals for all countries, but Latvia and to some extent the Slovak Republic. This means that the results presented in table 7.1 and table 7.2 provides valid t-values for all other countries, but the Latvian and the Slovakian data must be read with some caution[27].

[26] See Greene, W. (2003) pp 500-501 or Hayashi, F. (2000) pp 491-495. for further description of the Lagrange Multiplier (LM) test.
[27] Recall that the Latvian and the Slovakian inflation differential was not confirmed stationary, so next to overvalued t-values the results might also be spurious.

Table 7.1 Result from OLS regression of equation (21):

$$\left(Inflationdiff\_X\right)_t = c + \beta_0\left(Inflationdiff\_X\right)_{t-1} + \beta_1\left(deltaexchangerate\_X\right)_t + \beta_2\left(LPdiff\_X\right)_t + \mu_t$$

Country Sample period: 1997:Q2-2007:Q1	$\hat{\beta}_0$	$\hat{\beta}_1$	$\hat{\beta}_2$	R^2
Estonia	**0,805** (17,7)**	**0,356** (3,49)**	**0,008** (0,40)	**0,95**
Latvia	**0,912** (26,1)**	**0,025** (2,28)**	**0,051** (3,20)**	**0,96**
Lithuania	**0,911** (35,7)**	**0,006** (0,43)	**0,057** (3,26)**	**0,98**
The Slovak Republik	**0,892** (25,0)**	**0,052** (3,08)**	**0,123** (4,28)	**0,96**
Slovenia	**0,876** (19,9)**	**0,157** (3,49)**	**0,001** (0,05)	**0,98**

[a] The values in brackets are t-values. One asterisk (*) indicates significant at 10 % level, i.e. t-value above 1,7. Two asterisks (**) indicate significant at 5 % level, i.e. t-value above 2,05.

Table 7.2 Result from OLS regression of equation (22):

$$\left(Inflationdiff\_X\right)_t = c + \beta_0\left(Inflationdiff\_X\right)_{t-1} + \beta_1\left(deltaexchangerate\_X\right)_t + \beta_2\left(LPdiff\_X\right)_t$$
$$+ \beta_3 (Wagediff\_X)_{t-1} + \tau_t$$

Country Sample period: 1997:Q1-2007:Q1	$\hat{\beta}_0$	$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\beta}_3$	R^2
Estonia	**0,811** (17,0)**	**0,347** (3,29)**	**-0,002** (-0,07)	**-0,008** (-0,47)	**0,95**
Latvia	**0,91** (25,9)**	**0,023** (1,96)	**0,058** (3,18)**	**0,011** (0,80)	**0,96**
Lithuania	**0,911** (34,4)**	**0,006** (0,40)	**0,057** (3,02)**	**0,001** (0,09)	**0,98**
The Slovak Republik	**0,906** (27,9)**	**0,064** (4,07)**	**0,142** (5,33)**	**0,216** (3,04)	**0,97**
Slovenia	**NA**	**NA**	**NA**	**NA**	**NA**

[a] The values in brackets are t-values. One asterisk (*) indicates significant at 10 % level, i.e. t-value above 1,7. Two asterisks (**) indicate significant at 5 % level, i.e. t-value above 2,05.

Although the coefficient estimates presented in table 7.1 and 7.2 have valid t-values, they are not the ones we are interested in. Since a lagged endogenous variable is included on the right hand side the testable equations (21) and (22) need to be solved for the long run in order to give the coefficient estimates a correct interpretation. What indicates the long run is that there is no change in the variables from one period to the next (in this case meaning that the differentials are no longer varying, but stabilized at a certain level) and thus no prediction errors (i.e. the error term is zero). Solving equation (21) for the long run:

$$\left(Inflationdiff\_X\right)-\beta_0\left(Inflationdiff\_X\right)=c+\beta_1\left(deltaexchangerate\_X\right)+\beta_2\left(LPdiff\_X\right)$$

$$\Rightarrow\left(Inflationdiff\_X\right)=\frac{c}{1-\beta_0}+\frac{\beta_1}{1-\beta_0}\left(deltaexchangerate\_X\right)+\frac{\beta_2}{1-\beta_0}\left(LPdiff\_X\right) \qquad (23)$$

Solving equation (22) for the long run:

$$\left(Inflationdiff\_X\right)-\beta_0\left(Inflationdiff\_X\right)=c+\beta_1\left(deltaexchangerate\_X\right)+\beta_2\left(LPdiff\_X\right)$$

$$+\beta_3(Wagediff\_X)$$

$$\Rightarrow\left(Inflationdiff\_X\right)=\frac{c}{1-\beta_0}+\frac{\beta_1}{1-\beta_0}\left(deltaexchangerate\_X\right)+\frac{\beta_2}{1-\beta_0}\left(LPdiff\_X\right)$$

$$+\frac{\beta_3}{1-\beta_0}(Wagediff\_X) \qquad (24)$$

Equation (23) and (24) hence yields the final empirical solution to the problem that has been analyzed in this thesis. The coefficient estimates are found from table 7.1 and 7.2 by simply dividing the value of the different explanatory coefficient estimates on (1- $\hat{\beta}_0$).

One more thing has to be stressed: Even though we find the desired coefficient estimates by the calculation made in equation (23) and (24), the t-values of these estimates are not similar to the ones reported in table 7.1 and 7.2. These so called long run t-values are found by employing the *static long run solution* section in PcGive and these values, together with the calculated final coefficient estimates are presented in table 8.1 and 8.2[28].

The results in table 8.1 and 8.2 will be interpreted in detail in the next section when the Balassa-Samuelson effect is calculated, but two findings are worth highlighting right away. First, all significant estimates do have positive signs, as predicted in section 3.2, which

[28] How to find valid t-values to the long run solution estimators from the ECM estimators is not derived analytically in this thesis, but found by the help of PcGive only. For an analytical description see Bårdsen, G. (1989).

Table 8.1 Long run solution[29]. Equation (23):

$$\left(Inflationdiff\_X\right)=\frac{c}{1-\beta_0}+\frac{\beta_1}{1-\beta_0}\left(deltaexchangerate\_X\right)+\frac{\beta_2}{1-\beta_0}\left(LPdiff\_X\right)$$

Country Sample period: 1997:Q1-2007:Q1	$\frac{\hat{\beta}_1}{1-\hat{\beta}_0}$	$\frac{\hat{\beta}_2}{1-\hat{\beta}_0}$
Estonia	**1,827** (4,26)**	**0,042** (0,41)
Latvia	**0,285** (1,59)	**0,575** (2,54)**
Lithuania	**0,071** (0,42)	**0,639** (2,09)**
The Slovak Republik	**0,477** (2,54)**	**1,131** (2,78)**
Slovenia	**1,262** (4,49)**	**0,009** (0,046)

Table 8.2 Long run solution. Equation (24):

$$\Rightarrow\left(Inflationdiff\_X\right)=\frac{c}{1-\beta_0}+\frac{\beta_1}{1-\beta_0}\left(deltaexchangerate\_X\right)+\frac{\beta_2}{1-\beta_0}\left(LPdiff\_X\right)+\frac{\beta_3}{1-\beta_0}\left(Wagediff\_X\right)$$

Country Sample period: 1997:Q1-2006:Q2	$\frac{\hat{\beta}_1}{1-\hat{\beta}_0}$	$\frac{\hat{\beta}_2}{1-\hat{\beta}_0}$	$\frac{\hat{\beta}_3}{1-\hat{\beta}_0}$
Estonia	**1,836** (4,09)**	**-0,011** (-0,07)	**-0,04** (-0,46)
Latvia	**0,250** (1,45)	**0,641** (2,52)**	**0,118** (0,78)
Lithuania	**0,068** (0,39)	**0,642** (2,06)**	**0,011** (0,09)
The Slovak Republik	**0,676** (2,66)**	**1,506** (2,76)**	**2,3*** (1,96)
Slovenia	**NA**	**NA**	**NA**

[29] The values in brackets for both tables are t-values. One asterisk (*) indicates significant at 10 % level, i.e. t-value above 1,7. Two asterisks (**) indicate significant at 5 % level, i.e. t-value above 2,05.

indicate that a Balassa-Samuelson effect is present. Theory suggests that all coefficient estimates are equal to one, but, except for the Slovakian labour productivity estimate and the Slovenian exchange rate estimate, this does not seem to be the case. The results suggest that the coefficient estimates are significantly different from unity. Second, the relative wage growth differential does not seem to have a significant effect on the inflation differential. The only exception is the Slovakian Republic, but this result must be read with some caution since there are persistent, positive auto correlation in the residuals, leading to overvalued t-values. This, combined with the fact that no other wage growth differential results are significant and chart 6 above suggest an approximate wage growth equalisation in the country, I choose to assume that this result is spurious in the case of the Slovak Republic.

5.3 The Balassa Samuelson effect

For Latvia, Lithuania and the Slovak Republic, the empirical results in table 8.1 and 8.2 indicate that an increase in the relative productivity growth differential between the accession country and the Euro area has a positive impact on the inflation differential, which provides evidence that a Balassa-Samuelson effect is present. For Estonia no results concerning the impact of labour productivity growth turn out significant (as explained prior in the thesis I suspect that there are errors in the Estonian data). A depreciation of the nominal exchange rate vis-à-vis the euro has a positive, significant effect on the inflation differential for Estonia, the Slovak Republic and Slovenia.

The main purpose of this thesis is to examine whether a Balassa-Samuelson effect is present in five EMU accession countries. The calculation of this effect for each country over the whole sample period is done by multiplying the labour productivity coefficient estimate $\frac{\hat{\beta}_2}{1-\hat{\beta}_0}$ from table 8.1 and 8.2 above with the figure for the contribution of the productivity differential figure presented in table 3 in section 4. This product states how many percentage points of the inflation differential that can be explained by the relative productivity growth differential on average over the sample period. This so-called international Balassa-Samuelson effect is presented in table 9.1 below. Also the effect of changes in the exchange rate is reported in the table, calculated in the same way.

The possible effect of the relative wage growth differential is not reported since the results in table 8.2 suggest that it has no significant effect on the inflation differential[30]. That it has no effect seems, however, a bit odd. In section 4 above, the Estonian and Latvian inflation differential was interpreted as being driven by the relative wage growth differential over the sample period, but this does not seem to have been captured as a significant result in the estimation. As emphasized in section 4, this might be a result of errors in the statistical data. The results are nevertheless insignificant and I therefore choose to focus on equation (23) and the ancillary results reported in table 8.1, when calculating the Balassa-Samuelson effect.

Table 9.1 Calculation of the Balassa-Samuelson effect and the effect of changes in the nominal exchange rate over the whole sample period.

Sample period: **1997-2007**	The Balassa-Samuelson effect			The average effect of changes in the nominal exchange rate on the inflation differential		
COUNTRY	$\frac{\hat{\beta}_2}{1-\hat{\beta}_0}$ [a]	Contribution of productivity growth differential to inflation differential [b]	The Balassa-Samuelson effect [c]	$\frac{\hat{\beta}_1}{1-\hat{\beta}_0}$ [d]	Average change in the nominal exchange rate vis-à-vis euro [e]	The effect of changes in the nominal exchange rate on the inflation differential [f]
ESTONIA	**0,042** (0,41)	-0,361	**-0,015**	**1,827** (4,26)**	0,373	**0,682**
LATVIA	**0,575** (2,54)**	0,039	**0,022**	**0,285** (1,59)	0,369	**0,105**
LITHUANIA	**0,639** (2,09)**	0,577	**0,369**	**0,071** (0,42)	-3,425	**-0,243**
SLOVAK REPUBLIC	**1,131** (2,78)**	-1,078	**-1,219**	**0,477** (2,54)**	-0,373	**-0,178**
SLOVENIA	**0,009** (0,046)	0,702	**0,006**	**1,262** (4,49)**	3,477	**4,388**

The values in brackets are t-values, reported in order to specify which results that are significant. One asterisk (*) indicates significant at 10 % level, i.e. t-value above 1,7. Two asterisks (**) indicate significant at 5 % level, i.e. t-value above 2,05.

[a] The coefficient estimate from table 8.1 above.

[b] The figure in column *e* in table 3, section 4.

[c] Defined as the product of column *a* and *b*.

[d] The coefficient estimate from table 8.1 above.

[e] The figures in column *b* in table 3, section 4.

[f] Defined as the product of column *d* and *e*.

[30] Recall the discussion in the previous section for why the apparently significant result for the Slovak republic is assumed to be spurious.

Table 9.1 provides evidence of a Balassa-Samuelson effect in Latvia and Lithuania. The results for the Slovak Republic are significant, but have the wrong sign, which is puzzling. I am not able to find significant results for Estonia and Slovenia. In the case of Estonia I have argued in favour of errors in the data, while in the Slovenian case the indications are that the changes in the nominal exchange rate have been of most importance to the inflation differential. This is supported in table 9.1, stating that the strong depreciation of the Slovenian Tolar over the sample period can explain about 4,4 percentage points of the difference in inflation rates relative to the Euro area. Also for Estonia and the Slovak Republic there are significant evidence that changes in the nominal exchange rate have had a considerable effect on the inflation differential over the sample period.

Turning back to the significant results of the Balassa-Samuelson effect, it is small for Latvia and Lithuania when the whole sample period is considered. Faster productivity growth in the tradable versus non tradable sector vis-à-vis the Euro area can only explain 0,4 percentage points of the inflation differential in Lithuania and pitiably 0,02 percentage points in Latvia. As will come clear in table 9.2 below, however, the Balassa-Samuelson estimate in the two countries increases when only the last three years are considered. In Latvia the estimate is then 0,7, which is much higher than for the whole sample period, but still quite small. In Lithuania, on the other hand, the Balassa-Samuelson estimate increases to 2,2, which means that faster productivity growth in the tradable versus the non tradable sector vis-à-vis the Euro area can explain 2,2 percentage points of the inflation differential if only the last three years are considered, compared to 0,4 percentage points over the whole sample period. For the Slovak Republic the Balassa-Samuelson effect has the wrong sign, which is quite confusing since it indicates that the explanatory variables in this analysis only explain why the inflation differential is not higher than observed. A possible explanation for this is given below:

Table 3 (in section 4 above) reports that the development in the Slovak Republic over the sample period has been a negative relative productivity growth differential and an appreciation of the exchange rate (on average). This should lead to a smaller gap between the Slovakian and the EMU inflation rates, the two effects can together explain a decrease in the inflation gap of 1,4 percentage points. The reported average Slovakian-EMU inflation rate differential is 4,84 per cent over the sample period, which is quite high. Chart 4 above shows however that the differential was higher than this in the beginning of the sample period and that there has been a falling tendency in the inflation differential since then. The results hence indicate that 1,4 percentage points of this decrease is due to the two effects explained in table 9.1 and that the majority of this decrease is due to the Balassa-Samuelson effect.

Milhaljek & Klau (2004) has been used as a benchmark article in this thesis, mainly because they argue that their paper provides a more precise estimate of the Balassa-Samuelson effect. In their paper they find the effect to vary from 0,12 to 1,84 (the estimates corresponds to the ones calculated in column *c*, table 9.1) and they argue that these estimates are "considerably lower than those found in the early literature[31], but close to the estimates in the newer literature, which also finds little support for the Balassa-Samuelson effect in Central Europe".[32] The Balassa-Samuelson effect calculated in this thesis is even smaller than the one calculated by Milhaljek & Klau (2004). In their paper they do a mistake and mix up levels of prices and labour productivity with the change in the exchange rate, so it is difficult to say what the range of the effect would have been if the regression had been done on first differences, but the fact that their results are close to other estimates from newer literature, makes it possible for me to conclude that my results are lower than what has been calculated in previous studies.

There are several possible explanations for why the Balassa-Samuelson effect is so small, both in this thesis and in general. One of the leading weaknesses is the fact that labour productivity has to be used as a proxy for total factor productivity (TFP). This is, as explained earlier, due to the lack of reliable capital data for the countries in study, leaving labour productivity the "best we got", at least for now. Based on this, and on the fact that productivity is hard to measure in general, measurement errors can to some extent be expected. Using labour productivity as a proxy for TFP growth is a problem if the capital stock changes over time or if the assumption of equal labour intensity does not hold. Then the TFP growth and the labour productivity growth will be different.

The assumption concerning wage growth equalization has been investigated thoroughly in this thesis, with the result that even if wage growth is not fully equalized between sectors, it has no significant effect on the inflation differential. This is a somewhat puzzling result since

[31] See Halpern & Wyplosz (2001); Rother (2000); Kovács & Simon (1998).
[32] See Cipriani (2001); Egert et al (2002); Flek et al. (2002); Kovács (2002).

table 3 in section 4 above suggests that the wage growth differential *do* contribute to the inflation differential for all countries in study.

Another possible weakness is the many possible definitions of the inflation differential between the countries[33]. I have chosen to use the harmonized index of consumer prices (HICP) for all countries, based partly on the fact that it appeared to be very difficult to divide the consumer price index into comparable components, but mostly on the fact that an inflation differential based on the HICP is closest to what this thesis wish to investigate. My results are affected by this choice. The choice of sector division and the reliability of the statistical data also matters for how the results turn out.

That the Balassa-Samuelson effect is smaller when calculated in this thesis than in previous studies could be because of the newer data sample. It is often assumed that the Balassa-Samuelson effect becomes smaller along with the catch-up process. The effect has been stated as present in Eastern Europe since the convergence process started in 1992, but the analysis has been based upon data samples ending in 2002. The data sample in this thesis, however, stretch over a ten year period from 1997 to 2007, i.e. it includes more recent data. Have the development in recent years led to a lower overall Balassa-Samuelson effect? Table 9.2 below takes only the last three years development into account (the coefficient estimates from the regression are the same) and as can be seen there, this is definitely not the case. The estimate for the Balassa-Samuelson effect increases in Latvia and accelerate substantially in Lithuania. In the Slovakian case, a steady appreciation of the exchange rates the last couple of years have helped curbing inflation, accompanied by a negative productivity growth differential. This seems to have been a deciding factor for the fact that the Slovak Republic now stands first in line to join the Euro area.

The fact that the Balassa-Samuelson effect increases in Latvia and Lithuania means that the convergence process is far from over. The productivity growth differential has increased in recent years and when this coincides with pegging the exchange rate at a fixed rate towards the euro, as both countries have done in recent years, it is harder to control inflation since focus of monetary policy is on keeping a steady exchange rate, thus the inflation differential increases. From the Slovakian and Slovenian results presented in table 9.1 and 9.2, we see that changes in the nominal exchange rate vis-à-vis the Euro area seem to have a large effect on

[33] This point is elaborated in detail in section 3.3 above.

the inflation differential. Pegging the exchange rate at an early stage might therefore be unwise, since it leaves little stumbling room for monetary policy to dampen economic growth. This leads us back to the main question asked initially: can the inflation criteria be fulfilled for a country in convergence, or is the Maastricht bottleneck too tight? I try to answer this question, among others, in the next sections' concluding remarks.

Table 9.2 Calculation of the Balassa-Samuelson effect and the effect of changes in the nominal exchange rate over the three last years.

***Sample period:* 2004-2007**	The Balassa-Samuelson effect			The average effect of changes in the nominal exchange rate on the inflation differential		
COUNTRY	$\frac{\hat{\beta}_2}{1-\hat{\beta}_0}$ [a]	Contribution of productivity growth differential to inflation differential [b]	The Balassa-Samuelson effect [c]	$\frac{\hat{\beta}_1}{1-\hat{\beta}_0}$ [d]	Average change in the nominal exchange rate vis-à-vis euro [e]	The effect of changes in the nominal exchange rate on the inflation differential [f]
ESTONIA	**0,042** (0,41)	-0,542	**-0,023**	**1,827** (4,26)**	-0,002	**-0,003**
LATVIA	**0,575** (2,54)**	1,185	**0,681**	**0,285** (1,59)	2,695	**0,768**
LITHUANIA	**0,639** (2,09)**	3,438	**2,197**	**0,071** (0,42)	0,005	**0,00**
SLOVAK REPUBLIC	**1,131** (2,78)**	-1,233	**-1,394**	**0,477** (2,54)**	-3,931	**-1,878**
SLOVENIA	**0,009** (0,046)	-1,281	**0,011**	**1,262** (4,49)**	0,772	**0,974**

The values in brackets are t-values, reported in order to specify which results that are significant. One asterisk (*) indicates significant at 10 % level, i.e. t-value above 1,7. Two asterisks (**) indicate significant at 5 % level, i.e. t-value above 2,05.

[a] The coefficient estimate from table 8.1 above.

[b] The figure in column *e* in table 3, section 4.

[c] Defined as the product of column *a* and *b*.

[d] The coefficient estimate from table 8.1 above.

[e] The figures in column *b* in table 3, section 4.

[f] Defined as the product of column *d* and *e*.

6. Concluding remarks

This thesis seeks to investigate if a Balassa-Samuelson effect is present in five EMU candidate economies, in order to discover whether the observed inflation differentials between these countries and the Euro area can be explained by differences in relative labour productivity growth. During the investigation I have raised the question whether higher inflation rates in a converging economy should be taken as a proof of a healthy economy and not a warning sign if a Balassa-Samuelson effect is present, since that kind of higher inflation is “natural” and assumed to fade out, as the catch-up process approaches its completeness.

I find that the Balassa-Samuelson effect is present in Latvia and Lithuania and that the effect has increased rather than diminished in recent years. In the Latvian case the effect is relatively small, explaining approximately 0,02 percentage points of the inflation differential when estimated over the whole sample period and 0,7 percentage points when focusing on recent years. For Lithuania both the effect itself and its increase in recent years are larger, explaining about 0,4 percentage points of the inflation differential over the whole sample period and as much as 2,2 percentage points in recent years. This means that at least some of the differences in inflation rates between the accession country and the Euro area are due to a “natural” development. That the Balassa-Samuelson effect has been relatively large in Lithuania in recent years provides evidence of its presence when the country applied for EMU membership in 2006.

I was not able to find significant results for a Balassa-Samuelson effect in Slovenia and Estonia. For the Slovak Republic the Balassa-Samuelson estimate was significant, but had the wrong sign.

I have also found that changes in the nominal exchange rate vis-à-vis the Euro have an effect on the inflation differential between the accession country and the Euro area, but this effect is smaller than the one affecting through the relative labour productivity differential, for all countries but Slovenia. Slovenia was included in the analysis to see whether the Balassa-Samuelson effect had been present in the country on its way to EMU membership, in order to investigate the importance of the effect. I was, however, not able to find significant results for the existence of a Balassa-Samuelson effect in Slovenia, even though there has been a positive relative productivity growth differential on average over the sample period. Instead I have found that inflation has been driven mainly by a long lasting depreciation of the exchange rate and when this depreciation diminished, when the Slovenian Tolar stabilized, so did inflation and this seems to have been the main reason for why Slovenia has been able to curb inflation and fulfill all Maastricht criteria at the same time.

One of the assumptions made when calculating the Balassa-Samuelson effect is equal wage growth in the tradable and non tradable sector. I have tested this assumption by exploring the effect of a relative wage growth differential. The results turned out as not significant for all countries in study, even though non-uniform wage growth seem to have had an effect on the inflation differential when the development of the variables is studied graphically.

There are still weaknesses in the way the Balassa-Samuelson effect is calculated. Obtaining reliable total factor productivity data, investigating the degree of labour intensity in each sector and examine the sector division more closely should be of interest for further research on this topic.

In the introduction to this thesis I wondered if Lithuania and Estonia would have been members of the monetary union if the Balassa-Samuelson effect had been taken into account when they applied for membership in 2006. Due to insignificant results, I was not able to answer this for Estonia, but in the Lithuanian case I find it reasonable to conclude that they would. Table 9.2 suggests that approximately 2,2 percentage points of the difference in inflation rates between Lithuania and the Euro area in recent years is due to a Balassa-Samuelson effect. The membership approval process took place in the summer months of 2006. The recent data sample used to estimate the Balassa-Samuelson effect in table 9.2 includes the first quarter of 2007, so the estimate might be a bit overrated, but since Lithuania only exceeded the inflation criteria by 0,1 percentage points, this is quite irrelevant. If only a small fraction of the Balassa-Samuelson effect estimate had been adjusted for, as a sign of naturally, temporary, higher inflation that would fade away over time, Lithuania would have been member of the European monetary union today.

This thesis intended to estimate the Balassa-Samuelson effect and based on the results explore if the inflation criterion can be fulfilled for a country in convergence, or if the Maastricht bottleneck is too tight. The accession countries in study in this thesis seem to be able to fulfil the rest of the criteria, but struggle to curb inflation.

So, *is the bottleneck then too tight?* Since both Latvian and Lithuanian inflation are diverging from the EMU inflation rate at present, after fixing their exchange rate to the Euro, it is tempting to answer this question positively. When fulfilling the exchange rate criterion, the inflation criterion becomes more difficult to satisfy, since the monetary policy instrument focuses on keeping the exchange rate fixed. But the achievements in Slovenia speak against this conclusion. Slovenia has managed to curb inflation while keeping a steady exchange rate within the ERM II band, even though the contribution of the relative productivity growth differential has been higher on average in Slovenia than in the other countries. The difference from the Baltic countries is that the exchange rate has not been totally fixed, but allowed to fluctuate within the band after the depreciation of the Slovenian Tolar diminished. An answer to the question could therefore be that both criteria might be fulfilled at the same time by letting the exchange rate vary a little and by that open for the possibility to employ monetary policy as a tool in order to control inflation.

To take the Balassa-Samuelson effect into account when the Maastricht inflation criterion is derived, will ease the situation even more for the accession economies. If it is present in a country, as in the case of Lithuania and Latvia, it means that some of the inflation differential is a result of a “naturally” higher inflation that will fade out over time. Taking this into account and at the same time letting the exchange rate fluctuate within the band, could be enough to say that the Maastricht criteria are absolutely possible to fulfil all at the same time.

All countries in study are very eager to join the European monetary union and by that adopt the Euro. That is why they struggle so hard to fulfil the Maastricht inflation criterion. They must, however, be careful so that becoming a member of the EMU not comes at the expense of the convergence prospects with Western Europe, since they all want to catch up as soon as possible. As have been emphasized in this thesis the presence of a Balassa-Samuelson effect increases inflation, but this effect is not the only reason for why the inflation gap is large between the accession country and the Euro area.

As can be seen from table 6.1 and 6.2 in the previous section, the estimation of equation (14) and (20) provides a relatively low R^2, which indicates that other variables than the ones studied as explanatory variables in this thesis do have a considerable impact on the inflation differential. All countries in study have experienced a strong economic growth in all sectors over the last ten years (see chart B.1, Appendix B) and this results in high inflation. Inflation caused by high economic growth in all sectors, is also a "natural" phenomena, but this effect is not expected to fade out over time, instead it needs to be curbed by the help of policy instruments. When the exchange rate is pegged in a fixed relationship to the Euro, monetary policy is lost as a discretionary economic policy tool, leaving the job of cooling the economy to fiscal policy. The countries then face a dilemma; the economy needs cooling in order to control inflation and by that be able to fulfil the Maastricht inflation criterion, but too much fiscal tightening could stifle economic growth and hurt convergence prospects with Old Europe[34]. The executive director of the European Central Bank, Jürgen Stark, said in a speech given at the economic conference on central, eastern and south-eastern Europe in Frankfurt, 1 October 2007, that even if the countries are eager to adopt the Euro, they have to be sure they do not hurt the economic progress on the way. In other words: Wait until you are ready.

A question worth asking at the end is if the way the Maastricht criteria are formulated today are the most suitable formulation of entrance criteria to EMU membership.

The Maastricht criteria are extremely rigid at present, not using any discretion, as comes clear in the Lithuanian case, in two ways: First, the candidate country was refused membership because it had 0,1 percentage points higher inflation than what was required. This shows that 0,1 percentage points are 0,1 points too much, no tolerance of movement there. Second, Lithuania *would* have been admitted as an EMU member if the inflation rate at the point had been 0,1 percentage points lower, without any further consideration of the long-term projections of the economic performance. Given the situation in Lithuania today, with steadily increasing inflation, not being an EMU member can be an advantage since the opportunity of loosening the grip on the exchange rate and by that make use of the monetary policy tools in order to cool the economy, still is a possible choice.

A better approach to the EMU entrance criteria in the future could therefore be to allow for some discretion. If all criteria, but the inflation criterion is fulfilled and a long term projection

[34] The term "Old Europe" denotes the EU countries that have been members for some time, i.e. France, Belgium, Italy, Netherlands, Luxembourg, Spain, Portugal, Austria, Sweden, Finland, Denmark, Ireland, Great Britain, Greece and Germany.

of economic development suggests that everything is under control, then the existence of a Balassa-Samuelson effect could be decisive for whether the country should be admitted, even if it has not managed to completely fulfill the inflation criterion. [35].

The fact that all EMU countries need to agree on which countries should be offered EMU membership, indicates however, that opening up for discretion is a remote possibility.

[35] The suggestion of preserving the room for using judgement when making the final assessment of compliance with the Maastricht Criteria is supported by Schadler, et al. (2005).

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Statistisk sentralbyrå: www.ssb.no

Eurozone Watch: http://www.euro-area.org/blog/

Eurostat: ec.europa.eu/eurostat

EUs internettportal: www.europa.eu

The Wall Street Journal: www.wsje.com

Database: EcoWinPro. Provided by Norges Bank, the Central Bank of Norway.

Appendix

Appendix A

DERIVATION OF THE SOLUTION TO THE BALASSA-SAMUELSON MODEL[36]

From the first order conditions (3) – (6) it follows that:

$$R = (1-\gamma)A^T(k^T)^{-\gamma} \tag{A.1}$$

$$R = (1-\mu)\frac{P^{NT}}{P^T}A^{NT}(k^{NT})^{-\mu} \tag{A.2}$$

$$W = \gamma A^T(k^T)^{1-\gamma} \tag{A.3}$$

$$W = \mu\frac{P^{NT}}{P^T}A^{NT}(k^{NT})^{1-\mu} \tag{A.4}$$

where k^i denotes the capital-labour ratio, $i = T, NT$. Due to factor price equalisation the rental rate of capital and the wage level is the same in both sectors, R and W, respectively. R is given exogenously by the world rental rate on capital while W is determined in the tradable sector. The model has thus four equations at hand to solve for four unknowns namely $(W, k^T, k^{NT}, \frac{P^{NT}}{P^T})$. P^T is given exogenously by the assumptions of perfect competition in the world market and the "law of one price".

Solving (A.1) yields the capital-labour ratio for the tradable sector:

$$k^T = \left(\frac{R}{(1-\gamma)A^T}\right)^{-\frac{1}{\gamma}} \Rightarrow k^T = \left(\frac{(1-\gamma)A^T}{R}\right)^{\frac{1}{\gamma}} \tag{A.5}$$

Substituting the capital-labour ratio from (A.5) into (A.3) gives a solution for the wage level:

[36] This derivation follows Nelson C. Mark (2001): International Macroeconomics and Finance – Theory and Econometric Methods., p. 168-170. Blackwell Publishing.

$$W = \gamma A^T \left(\frac{(1-\gamma)A^T}{R} \right)^{\frac{1-\gamma}{\gamma}} \Rightarrow \gamma (A^T)^{\frac{1}{\gamma}} \left(\frac{(1-\gamma)}{R} \right)^{\frac{1-\gamma}{\gamma}} \tag{A.6}$$

Inserting the solution for the wage level from (A.6) in (A.4) a solution for the capital-labour ratio for the non tradable sector is retrieved:

$$k^{NT} = \left(\frac{\gamma (A^T)^{\frac{1}{\gamma}} \left(\frac{(1-\gamma)}{R} \right)^{\frac{1-\gamma}{\gamma}}}{\mu \frac{P^{NT}}{P^T} A^{NT}} \right)^{\frac{1}{1-\mu}} \tag{A.7}$$

Putting in for the non tradable capital-labour ratio in equation (A.2) then provide the final solution for the relative price of non tradables in terms of tradables:

$$R = (1-\mu) \frac{P^{NT}}{P^T} A^{NT} \left(\frac{\gamma (A^T)^{\frac{1}{\gamma}} \left(\frac{(1-\gamma)}{R} \right)^{\frac{1-\gamma}{\gamma}}}{\mu \frac{P^{NT}}{P^T} A^{NT}} \right)^{\frac{-\mu}{1-\mu}}$$

$$\Rightarrow \left(\frac{P^{NT}}{P^T} \right) = \frac{R^{1-\mu} \left(\gamma (A^T)^{\frac{1}{\gamma}} \left(\frac{(1-\gamma)}{R} \right)^{\frac{1-\gamma}{\gamma}} \right)^{\mu}}{(1-\mu)^{1-\mu} \mu^{\mu} (A^{NT})^{1-\mu} (A^{NT})^{\mu}}$$

rearranging terms:

$$\Rightarrow \frac{P^{NT}}{P^T} = \frac{R^{1-\mu-\frac{(1-\gamma)\mu}{\gamma}} \gamma^{\mu} (A^T)^{\frac{\mu}{\gamma}} (1-\gamma)^{\frac{(1-\gamma)\mu}{\gamma}}}{(1-\mu)^{1-\mu} (A^{NT})^{1-\mu+\mu} \mu^{\mu}}$$

$$\Rightarrow \frac{P^{NT}}{P^{T}} = \frac{\gamma^{\mu}(1-\gamma)^{\frac{(1-\gamma)\mu}{\gamma}}}{(1-\mu)^{1-\mu}\mu^{\mu}} \frac{(A^{T})^{\frac{\mu}{\gamma}}}{A^{NT}} R^{\frac{\gamma(1-\mu)-\mu(1-\gamma)}{\gamma}}$$

$$\Rightarrow \frac{P^{NT}}{P^{T}} = C \frac{(A^{T})^{\frac{\mu}{\gamma}}}{A^{NT}} R^{\frac{\gamma-\mu}{\gamma}} \tag{A.8}$$

Taking logs lead to the solution for the log relative price of non tradables in terms of tradables (lower-case letters indicate logs):

$$p^{NT} - p^{T} = \frac{\mu}{\gamma} a^{T} - a^{NT} + \frac{\gamma-\mu}{\gamma} \log(R) + c \tag{A.9}$$

The solution to the Balassa-Samuelson model shows that the log relative price of non tradables in terms of tradables depends on technology (TFP) and the exogenous rental rate on capital.

Appendix B

DATA AND VARIABLE DESCRIPTION

Some weaknesses regarding the data

Some trouble arose during the process of collecting these data. The Estonian value added data were discontinued in 2000 due to methodological changes and the data reported from 2000:Q1 hence rely on the updated technology, as a result of which the economic growth increased compared to previous published data. Since linking the two series together did not create any structural breaks or other visible disturbances in the data set, it will be used in the analysis, but under the awareness of the methodology being somewhat different from the year 2000[37]. Value added data for Lithuania and the Slovak Republic were only available in current prices and was therefore converted into constant prices to be comparable with the other series[38].

[37] This information was received by email from the Statistical Office of Estonia.
[38] This was done by the help of the Lithuanian consumer price index, obtained from the Statistical Office of Lithuania and the HICP for the Slovak Republic, both with base year 2005.

When collecting the employment data there were bumps in the road as well. For Latvia and Lithuania quarterly data only exist from 2001:Q4, before that half-yearly from 1998:Q1 and prior to that only yearly. Quarterly data for 1998:Q1 – 2001:Q3 were created by letting the reported biannual data be Q2 and Q4 and then taking an average of the two for the quarters in between. For both Latvia and Lithuania weights of each category's employment in total employment, as well as total employment were reported quarterly from 1996:Q1. Quarterly employment for each sector was then derived in the following way:

$$\sum(\text{"quarterly weight in total employment, category X"} \bullet \text{"total employment"})$$

The latter was also done on Estonian data from 1996, since quarterly data are first reported from 1997:Q1. The first three years of Slovenian labor productivity data must be taken with caution as employment data in that period are only reported yearly.

ALGEBRAIC CODES FROM CREATION OF VARIABLES IN GIVEWIN2

The inflation differential

```
Inflationdiff_EST=Estonia_inflation-EMU_inflation;
Inflationdiff_LAT=Latvia_inflation-EMU_inflation;
Inflationdiff_LIT=Lithuania_inflation-EMU_inflation;
Inflationdiff_SLOVAK="Slovak Rep._inflation"-EMU_inflation;
Inflationdiff_SLOVEN=Slovenia_inflation-EMU_inflation;
```

The relative labour productivity growth differential

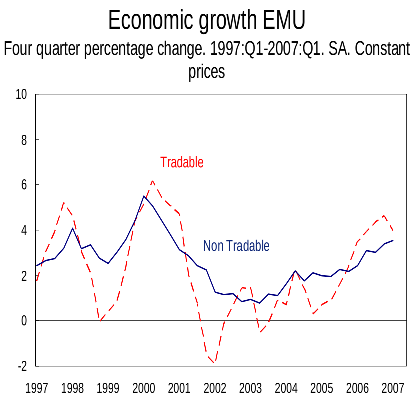
```
LPdiff_EST=("Estonia_(1-Alpha)"*(EST_Lpgrowth_T-EST_Lpgrowth_NT))-("EMU_(1-
Alpha)"*(EMU_Lpgrowth_T-EMU_Lpgrowth_NT));
LPdiff_LAT=("Latvia_(1-Alpha)"*(LAT_Lpgrowth_T-LAT_Lpgrowth_NT))-("EMU_(1-
Alpha)"*(EMU_Lpgrowth_T-EMU_Lpgrowth_NT));
LPdiff_LIT=("Lithuania_(1-Alpha)"*(LIT_Lpgrowth_T-LIT_Lpgrowth_NT))-
("EMU_(1-Alpha)"*(EMU_Lpgrowth_T-EMU_Lpgrowth_NT));
LPdiff_SLOVAK=("Slovak Rep._(1-Alpha)"*(SLOVAK_Lpgrowth_T-
SLOVAK_Lpgrowth_NT))-("EMU_(1-Alpha)"*(EMU_Lpgrowth_T-EMU_Lpgrowth_NT));
LPdiff_SLOVEN=("Slovenia_(1-Alpha)"*(SLOVEN_Lpgrowth_T-
SLOVEN_Lpgrowth_NT))-("EMU_(1-Alpha)"*(EMU_Lpgrowth_T-EMU_Lpgrowth_NT));
```

The relative wage growth differential

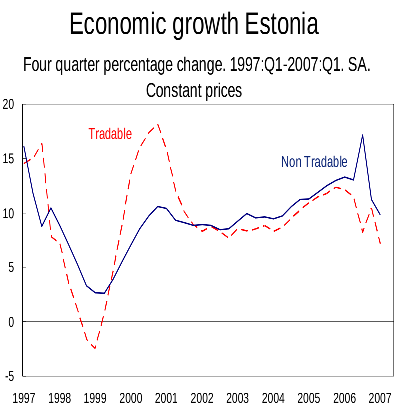
```
Wagediff_EST=("Estonia_(1-Alpha)"*(EST_Wagegrowth_NT-EST_Wagegrowth_T))-
("EMU_(1-Alpha)"*(EMU_Wagegrowth_NT-EMU_Wagegrowth_T));
Wagediff_LAT=("Latvia_(1-Alpha)"*(LAT_Wagegrowth_NT-LAT_Wagegrowth_T))-
("EMU_(1-Alpha)"*(EMU_Wagegrowth_NT-EMU_Wagegrowth_T));
Wagediff_LIT=("Lithuania_(1-Alpha)"*(LIT_Wagegrowth_NT-LIT_Wagegrowth_T))-
("EMU_(1-Alpha)"*(EMU_Wagegrowth_NT-EMU_Wagegrowth_T));
Wagediff_SLOVAK=("Slovak Rep._(1-Alpha)"*(SLOVAK_Wagegrowth_NT-
SLOVAK_Wagegrowth_T))-("EMU_(1-Alpha)"*(EMU_Wagegrowth_NT-
EMU_Wagegrowth_T));
```

CHART B.1

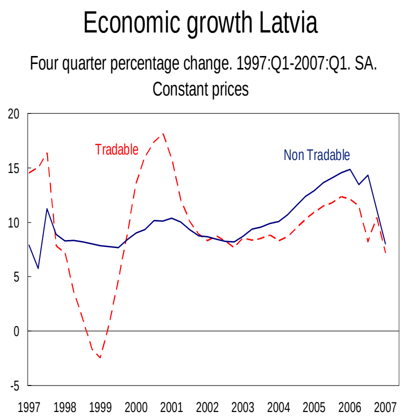
Four quarter percentage change in value added for all countries and the Euro area.



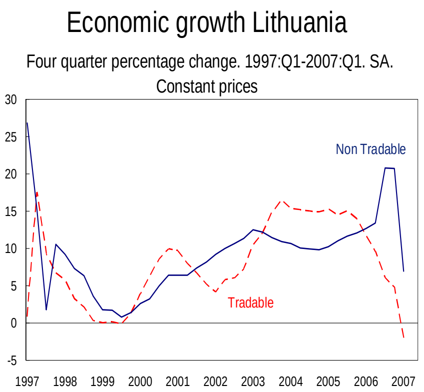
Source: EcoWin



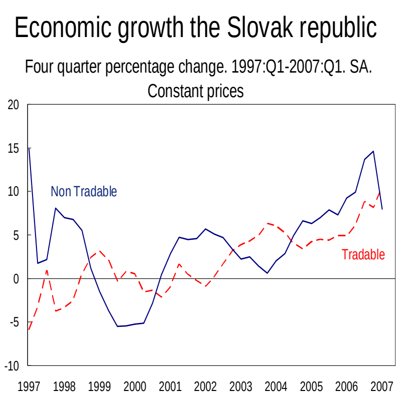
Source: EcoWin



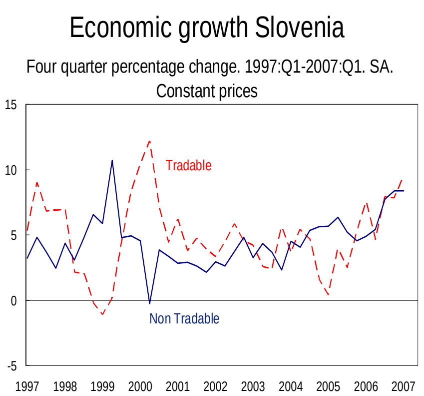
Source: EcoWin



Source: EcoWin



Source: EcoWin



Source: EcoWin

Appendix C

AUGMENTED DICKEY FULLER UNIT ROOT TEST

The table yields the critical values of a Dickey Fuller Unit Root test.

Table C.1 Critical values for the Dickey-Fuller one sided test.

AR (1) Model **Level of rejection**	**Sample size**	
	25	**50**
0,01	-2,66	-2,62
0,025	-2,26	-2,25
0,05	-1,95	-1,95
0,10	-1,60	-1,61

A unit root test is testing for the existence of stationarity in the data. To give an example of the difference between a stationary and non stationary time series, consider equation (C.1) which is an autoregressive model with one lag (an AR(1) model):

$$x_t = \rho x_{t-1} + \mu_t \tag{C.1}$$

where μ_t is assumed to be *iid* $N \sim (0,1)$. If the autoregressive coefficient ρ equals one, then a shock in period t-1 will be fully passed through to period t. A shock in period t, i.e. $\mu_t \neq 0$, will be passed through fully to the next period and so on. Then variable sequence *x* is said to follow a random walk. If $0 < \rho < 1$ the series are said to be stationary since a shock to the variable is assumed to fade out over time. The closer to one ρ is, the more persistent is the shock.

In this thesis a variable is defined as non-stationary if the first difference of the variable is stationary. The literature refer to such variables as variables that are integrated of degree 1,

(I(1) is then a typical notation). A variable that follows a random walk process is a well known example. Due to the unit-root of the process, any shocks to the variable will have permanent effects.

The Augmented Dickey-Fuller unit root tests check for this type of non stationarity. The null hypothesis is that the variable is precisely a random walk ($\rho = 1$)[39]. The maximum lag-order chosen in this thesis is 4.

[39] The difference between a regular Dickey-Fuller test and an augmented version is that while the former is based on an equation equal to equation (C.1), where the error term is iid, the latter makes allowances for auto correlation in the residuals.